Expert Group on Nuclear Radiation Safety

REPORT on

Environmental radiation monitoring programmes among the members and observers of the Council of the Baltic Sea States
The Council of Baltic Sea States (CBSS) was established in 1992 by the governments of Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, and Sweden in order to promote co-operation among the states in the region. These 11 states and the European Commission are current members of the CBSS. In addition, Belarus, France, Italy, Netherlands, Romania, Slovakia, Spain, Ukraine, the UK, and the USA serve as CBSS observer states.

As part of this co-operation, a number of expert groups have been established to address specific issues. One of these groups, the Expert Group on Nuclear and Radiation Safety (EGNRS), has a mandate to exchange information and coordinate efforts to increase nuclear and radiation safety in the Baltic Sea States, including collecting information about radioactivity in the environment and making recommendations to enhance nuclear and radiation safety in the region.

As a fulfilment of this mandate, the EGNRS has discussed the possibility of extending the exchange of monitoring data for radioactivity, which already takes place for external gamma radiation and airborne radionuclides, to other environmental compartments as well. In order to gain the necessary background information for evaluating the feasibility of such a task, the EGNRS Working Group on environmental monitoring has in co-operation with the national governments collected information about the national environmental radiation monitoring programmes in the region and generated an overview of the existing variability between these programmes. Information has been collected from all eleven CBSS member states and two of the observer states.

The survey shows that the countries in the region are monitoring many of the same sampling media and that the programmes are somewhat harmonised. Nevertheless, many monitoring details still vary significantly in many cases, including which radionuclides are measured, which sampling and analytical methodologies are used, and which physical quantities and units are reported. Consequently, the monitoring data from the different countries in the CBSS is often not directly comparable.

The EGNRS sees many advantages to exchanging data on radioactivity in the environment between the individual CBSS states. However, the survey shows that in order for these data to be directly comparable across borders, parts of the existing national monitoring programmes would need to be harmonised.

In April 2011, the EGNRS held a Topical Day on monitoring of radioactivity in the environment, inviting representatives from all member and observer states to attend. The Topical Day participants discussed the benefits, concerns and feasibility related to the potential of harmonising and sharing environmental monitoring data within the CBSS.

The participants of the Topical Day recognised the benefit of being able to share comparable data across the region, but also expressed concern that a too ambitious approach would create a too large workload and financial burden. It was therefore suggested that the important tasks that are also the most manageable and least complex should be prioritised in the initial phase of such a process. Furthermore, the participants suggested that best practices and guidelines for the most appropriate approaches to monitoring radioactivity in the environment should be defined, thereby providing a helpful tool that would serve as a step towards voluntary harmonisation, while at the same time enhancing the quality of existing monitoring programmes. Because the main purpose of this work is to communicate comparable and interpretable data, the data sharing process in itself will also require careful consideration, particularly regarding the choice of the format standard and the inclusion of appropriate metadata.

Considering the need to avoid creating too much work and a too large financial burden all at once, it was suggested that the best approach would be to proceed by developing smaller projects that are limited in time and scope in the initial stages of the process.

Based on these discussions that took place at the Topical Day and the findings and evaluations of the Working Group on environmental monitoring, the EGNRS recommends that a new Working Group should be established to generate specific project proposals for improving the environmental monitoring of radioactivity in the region. This Working Group should prioritise projects that lead to (a) the development of best practices, (b) the harmonisation of physical quantities and units, (c) the harmonisation of recorded and reported parameters for the prioritised sampling media, (d) the establishment of a joint format for data exchange, and (e) the development of a guideline defining which radionuclides should be measured as a minimum standard in each sampling medium.
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1.1. What are the Council of the Baltic Sea States and the Expert Group of Nuclear and Radiation Safety?

The Council of the Baltic Sea States (CBSS) is a forum for intergovernmental regional cooperation on a variety of topics of international relevance. Its members are the eleven states Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, and Sweden, as well as the European Commission. In addition, the CBSS has ten observer states: Belarus, France, Italy, Netherlands, Romania, Slovakia, Spain, Ukraine, the UK, and the USA.

Figure 1. CBSS member states and observer states in Europe. In addition to the states shown in this figure, the USA is also an observer state.

The CBSS has several expert groups that focus on specific issues. The CBSS Expert Group on Nuclear and Radiation Safety (EGNRS) consists of representatives from member and observer states’ representative national radiation authorities. The main tasks of the EGNRS are

- to collect information about nuclear facilities and waste storage in the Baltic Sea Region;
- to identify the sources of radioactivity which pose a potential risk in the Baltic Sea Region;
- to identify potential nuclear and radiological risks that require immediate concerted remedial action;
- to take stock of and monitor various projects aimed at enhancing nuclear and radiation safety in the Baltic Sea Region, and to prepare relevant recommendations as well as to suggest and develop initiatives accordingly.

According to the EGNRS’s terms of reference, one of the group’s tasks is to “...identify sources of radioactive materials which constitute a potential risk to life, health or the environment in the Baltic Sea States and prepare relevant recommendations accordingly.” To this end, the terms of reference further states that the EGNRS should “collect and collate information [...] about levels of radioactive materials in the environment in the Baltic Sea States” (1). In accordance with this mandate, the EGNRS ad hoc Working Group on Environmental Monitoring was established to perform a survey of the national monitoring programmes for radioactivity in the environment, to be used as a tool in the further work to evaluate the potential for harmonising the existing monitoring programmes and sharing the monitoring results between the different countries in the region.
The CBSS member states have also all signed the Agreement on the Exchange of Radiation Monitoring Data (2), in which the contracting Parties agree to “make available to the other Parties updated information and data from their own national radiation monitoring networks they have available themselves”. In practice, this sharing currently only includes monitoring data for air and external gamma dose rates, although the agreement does not specify or limit itself to the sharing of only air and gamma dose rate data.

1.2. Objective of the survey

When monitoring radioactivity in the environment, the various members and observers of the CBSS are to a large extent analysing the same types of sampling media, or sample types, such as air, marine biota, or drinking water. However, the methods used when sampling and analysing the various media often differ among the various national radiation monitoring programmes. (Differences in the methods used can include, for example, which radionuclides are analysed, how the media is sampled, or how the sample is prepared.) When different methods are used, the results of the different national monitoring programmes may not be directly comparable across borders. If our current methods could be harmonised, however, all participants would have the opportunity to share this information and to learn more about the radiation levels and dispersion patterns in the environment on a larger scale, far beyond the geographic coverage of the individual national programmes.

Some multilateral environmental radiation programmes are already in place; however, these include only a subset of the environment compartments that are monitored in the national programmes. Furthermore, none of the existing multilateral programmes include all of the CBSS countries. In other words, none of the existing programmes cover the whole environment or the whole region. Our ultimate ambition is therefore for the CBSS member and observer states to harmonise the national and multilateral regional programmes in order to create what would essentially be one virtual multilateral programme where comparable and consistent results are available to all member states.

The benefits of being able to share comparable data over the whole region would include:

- a more cost-effective environmental monitoring programme by avoiding redundancies and filling gaps
- a better and broader basis for detecting and responding to abnormal situations
- a better and broader basis for more complete information to the public
- a better basis for maintaining compatible measurement capabilities for emergency response
- a better and broader basis for predicting movement of radioactive materials in the environment

1.3. Collecting information

Before assessing the feasibility of harmonising the environmental radiation monitoring programmes in the CBSS region, it was necessary to gather information about the current national programmes carried out in the CBSS states, in order to get an overview of the current monitoring practices in the region.

In December 2009, the EGNRS ad hoc Working Group on environmental monitoring sent out a questionnaire to the CBSS observer and member states, requesting information from the relevant national authorities regarding the following details for each sampling medium in their environmental radiation monitoring programmes: geographic coverage, number of sampling sites, frequency, sample type, radiation measurement and analysis, sample size, detection method, and detection limit. The available information for each sampling medium was subsequently reorganised into a large table that gave an overview according to attributes defining the radionuclides measured, sampling/measurement frequencies, sample details, detection methods, detection limits, and sample sizes, and the attribute reporting unit was also added as this was identified as another possible source of data incompatibility. This new table was then sent out to the member states and the observer states that had previously responded. The participating countries were asked to verify their information and to fill in missing information, while the remaining member states again were encouraged to participate.

Eight member states (Finland, Germany, Estonia, Latvia, Lithuania, Norway, Poland, and Russia) and one observer state (Romania) submitted completed questionnaires. One member (Denmark) and one observer (Netherlands) instead submitted their Euratom Article 35 technical reports in reply to the Working Group’s request. In addition, publically available reports were used to collect information for the two
member states that have not responded to the survey (Iceland (3, 4) and Sweden (5)). In summary, information has been collected for all of the eleven CBSS member states and two of the observer states.

It should be noted that the information collected from Russia is based only on the monitoring programme of the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet). This organisation is in charge of the monitoring of radioactivity in most of the abiotic media. (Information for Russia has therefore only been collected for external gamma dose rate, air, deposition, soil, surface freshwater, freshwater sediments, seawater, and marine sediments). Other organisations are responsible for monitoring foodstuffs and other biotic media in Russia, and information regarding these sampling media is not currently available.

The collected information has been verified by nine of the eleven member states (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland and Russia) and none of the two observer states that responded to the survey.

Based on the information that was obtained, 16 general categories of sampling media were identified:

- Ambient external gamma radiation
- Air
- Atmospheric deposition
- Soil
- Surface freshwater
- Freshwater biota
- Freshwater sediments
- Drinking water (and/or ground water)
- Seawater
- Marine biota
- Marine sediments
- Milk
- Food products
- Mixed diet (complete meals or average diet)
- Indicator biota
- Sewage

In addition, three of the countries (Finland, Lithuania, Norway) reported that they are performing whole body measurements. However, the EGNRS decided that this monitoring category should be excluded from further evaluation at this stage due to its low relevance for international use and because very few countries are performing these measurements.

It should be noted that Germany also reported to be monitoring some sampling media that did not fit into any of these above-mentioned categories (namely, suspended matter in freshwater; suspended matter in seawater; animal feed; groundwater leachate near landfills; composting plants; and filter ash slag, scrubbers, and waste water at waste incinerator plants). However, since no other countries reported to be analysing these media, and did not appear highly relevant to the international community, it was decided that they should be excluded from the evaluations for the time being.

With this overview of the current state of environmental radiation monitoring programmes in the CBSS region as a basis, the EGNRS was better equipped to evaluate how large the potential changes would need to be in order to harmonise the programmes and share the monitoring results.

1.4. CBSS EGNRS Topical Day on monitoring of radioactivity in the environment

In the autumn of 2010, it was decided that the CBSS EGNRS should organise a Topical Day workshop in order to discuss environmental monitoring of radioactivity and the potential for harmonising the national environmental monitoring programmes for radioactivity in the CBSS countries and sharing these monitoring data. Topical Days are a series of in-depth EGNRS seminars on topics that are highly relevant to the group.

It was the decided that the Topical Day on monitoring of radioactivity in the environment should be held in Oslo, Norway, on 12-13 April 2011. The CBSS members and observers were invited, with the request that the national radiation safety authorities organise attendance from relevant persons in their respective countries/organisations. The objective of the seminar was for the discussions to result in recommendations to the Working Group on how to proceed and what to prioritise in the work ahead.

Participating in the Topical Day were representatives from Denmark, Estonia, Finland, Germany, Lithuania, Norway, Poland, Russia, Sweden, and the EC. None of the observer states attended.
The seminar presented experiences from current multilateral co-operation in the field of monitoring of radioactivity in the environment, including presentations from HELCOM, OSPAR and the EC, as well as an overview of the current variability among national environmental radioactivity monitoring programmes. A draft version of this report was also distributed to the participants beforehand. The participants took part in topical breakout sessions, in which the participants were divided into four groups focusing specifically on the atmospheric, marine, terrestrial environments and on foodstuffs. Issues related to the feasibility and priorities for harmonisation and data sharing were discussed in the groups, and the groups’ findings and other general issues were subsequently discussed among all participants.

Immediately following the Topical Day seminar, the EGNRS also held their regular semi-annual meeting, and some of the issues that were discussed in the Topical Day were also briefly discussed in this EGNRS meeting.

The discussions and the recommendations made by the participants of the Topical Day and the EGNRS meeting are reflected in the discussions of chapter 5 of this report, and also serve as the basis for the conclusions made in section 6 and the outline for further work defined in section 7.

2. OVERVIEW OF MULTILATERAL ACTORS AND AGREEMENTS

2.1. The Council of the Baltic sea States

The CBSS is an intergovernmental political forum working to resolve challenges in the Baltic Sea region on a range of issues regarding the environment, economic development, energy, education and culture, and civil security and the human dimension. The CBSS therefore has multilateral agreements on many different subjects.

The agreement that is relevant to the field of radiation safety is the Agreement on the Exchange of Radiation Monitoring Data of 7 June 2001 (2), developed by the EGNRS. This is a binding agreement for all parties to exchange updated radiological data with the other parties in normal and emergency situations and without delay. It has been signed by all CBSS member states. The objective of the agreement is to improve “situation assessments, decisions and public information”. Currently, the CBSS members only share monitoring data for external gamma dose rate and air; however, the agreement does not specify or limit the data exchange to these sampling media.

2.2. The European Atomic Energy Agency (Euratom)

The European Atomic Energy Agency (Euratom) is a separate organisation from the European Union (EU), but it consists of the same member states (Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom). All of the CBSS member states are members of Euratom, except Iceland, Norway, and Russia.

Commission recommendation 2000/473/Euratom

Article 35 in Euratom Treaty (6) states that "Each Member State shall establish the facilities necessary to carry out continuous monitoring of the level of radioactivity in the air, water and soil and to ensure compliance with the basic standards". Article 36 gives the member states the obligation to periodically report the results of this monitoring. In addressing these obligations, the Commission issued recommendation 2000/473/Euratom (7), recommending that each member state should define a sparse and a dense monitoring network for each of the named sampling media. The recommendation defines which radionuclides should be measured, sampling frequency, reporting levels, and in part the sampling strategy for each required sampling medium (air, external ambient gamma dose rates, surface water, drinking water, milk, and mixed diet) within a sparse and a dense network. (The sparse and dense networks should monitor the same media, but the sparse network – which may consist of fewer sites, but at least one per region – should have a higher measurement frequency and have stricter requirements for sensitivity and detection limits than the dense network.)

The European Radiological Data Exchange Platform (EURDEP)

The European Radiological Data Exchange Platform (EURDEP) is the European Commission’s platform for the sharing of radiological automatic monitoring data for external gamma dose rate and air in near real-time. Each participating country has access to the other participants’ data, and most of the data is also available to the public with some time delay. EURDEP currently receives information from 33 participating countries. These are the EU member states plus Croatia, Iceland, Norway, Russia, Switzerland, and Turkey. All CBSS member states are, in other words, part of this cooperation.
In a radiological emergency, the participants would update the data more frequently. Currently, EURDEP only includes the monitoring data for external gamma doserate and air. Due to the significance of external gamma radiation in an emergency situation and the near-instant sampling and sharing of these data, the EURDEP network is highly relevant to emergency preparedness.

### 2.3. The Helsinki Commission (HELCOM)

The Baltic Marine Environment Protection Commission (the Helsinki Commission, HELCOM) is an intergovernmental organisation that works to protect the Baltic Sea from all sources of pollution. HELCOM covers only the marine environment. The contracting parties currently consist of Denmark, Estonia, the European Community, Finland, Germany, Latvia, Lithuania, Poland, Russia, and Sweden. This includes all of the CBSS member states except Norway and Iceland.

HELCOM is the governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1992 (the Helsinki Convention), in which the contracting parties “undertake to prevent and eliminate pollution of the Baltic Sea Area caused by harmful substances from all sources” (8). To this end, the HELCOM Monitoring and Assessment Group (MONAS) issued HELCOM Recommendation 26/3, which recommends that the contracting parties follow the Guidelines for Monitoring of Radioactive Substances (9). The guidelines specify some sampling method details, and it assigns the sampling sites for seawater, sediments, fish, aquatic plants, and benthic animals for each country. All sampling is to be performed once per year, and for each sampling medium, there is a list of “obligatory” and “voluntary” radionuclides to be monitored. In their reporting to HELCOM, the countries are among other things also asked to specify the names of the species, which tissues are measured, and which sediment types were sampled.

### 2.4. The OSPAR Commission

The OSPAR Commission is an intergovernmental organisation working to protect the marine environment in the North-East Atlantic. The 15 current participating countries are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom, in addition to the European Community. OSPAR does not include the CBSS member states Estonia, Latvia, Lithuania, and Russia. OSPAR only covers the marine environment.

The Convention of the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention) requires the contracting parties to “take all possible steps to prevent and eliminate pollution and to take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected” (10).

The convention also includes an agreement (Agreement on a Monitoring Programme for Concentrations of Radioactive Substances in the Marine Environment) (11), which states which radionuclides each party should measure in each sampling medium (seawater, fish, mollusks, and seaweed), the sampling frequency, and the sampling location. Changes to monitoring stations and frequencies may be changed, however, as long as these “do not undermine the general framework” of the monitoring programme.

### 2.5. The Arctic Council

The Arctic Council is an intergovernmental forum that focuses on specific issues concerning the eight Arctic governments and its indigenous people. Its members are Canada, Denmark, Finland, Iceland, Norway, Sweden, Russia, and the USA. This includes a few of the CBSS member states, but not Estonia, Latvia, Lithuania, Poland, nor Germany, nor the EC.

One of the Arctic Council’s five working groups is the Arctic Monitoring and Assessment Programme. AMAP targets both the marine environment and the terrestrial environment, but only the portions of the sea and the member states’ land area that lie within the “AMAP region”, a modified version of other geographical definitions of the Arctic region (for more information, see www.amap.no) (12). AMAP organises a coordinated monitoring programme of different contaminants, including radionuclides, and assesses the pollution status and trends of the Arctic ecosystems. Their monitoring programme is based on collecting data from existing national and international programmes (but only from the sampling sites that lie within the AMAP region), and they are also aiming to harmonise these programmes as much as possible.
3.1. Objectives for monitoring radioactivity in the environment

The questionnaire that was distributed for this survey also asked the radiation authorities of CBSS members and observers to identify their objectives for monitoring radioactivity in the environment, in addition to filling out their monitoring programme details. Some of the Euratom Article 35 technical reports that were used to compile information also clearly stated the monitoring programme objectives, and these objectives were also included in the following overview.

The responses for the monitoring programme objectives varied widely. It should of course be acknowledged that countries can have other objectives in addition to those declared. In general, the stated objectives fall into these basic categories:

- Estimating doses to the public
- Documenting levels and trends
- Providing background information for research
- Providing information to the public
- Controlling/reducing exposure to the public
- Facilitating data exchange with neighbouring countries
- Controlling discharges from facilities
- Complying with legislation and agreements
- Providing a warning in case of a radiological emergency
- Maintaining competence for emergency situations

These different reasons for performing monitoring should be kept in mind when looking at the overview of the national programmes, seeing as the monitoring objectives can have an effect on the choices that are made regarding which sampling media are monitored, which methods are used, and also how much a country would benefit from having access to the data from the larger region. For example, countries whose main objectives include research and emergency warnings would be likely to have more benefits from sharing radiological information across borders than, say, those whose main objectives involve having control of discharges and complying with legislative requirements.

3.2. Survey observations for existing national environmental radioactivity monitoring programmes

The following pages give an overview of the monitoring programmes in all 11 member states and two of the observer states, based on the information that the Working Group has been able to collect. More detailed information regarding methodologies is also available upon request.

It should be noted that the process of producing monitoring results consists of several stages:

- Sampling
- Sample preparation
- Measurement and analysis
- Reporting

It should further be noted that there might be several different ways of carrying out all these tasks and that the reported results depend on the procedures applied in all of them. It is therefore not a simple task to describe these procedures in full detail. The response to the questionnaire described below should therefore be understood as a generic and simplified description of the methods applied and results reported.
3.2.1. External ambient gamma radiation

All thirteen countries that the Working Group has been able to collect information from monitor external gamma dose rates. In all cases, external gamma dose rates are measured continuously and reported several times per day. (The reporting frequency varies somewhat from country to country.) The number of external gamma dose rate monitoring stations differs, with Germany having the densest network with approximately 1800 stations.

Three of the countries also perform external ambient gamma spectrometry measurements to identify the specific gamma emitters present.

It should be noted that external gamma dose rate monitoring in the CBSS member states has already been harmonised to large extent through both the CBSS and EURDEP, and data is already being exchanged via these two platforms.

Table 3.1. Key summary of external ambient gamma monitoring in member and observer states from which the Working Group was able to acquire information (eleven members and two observers).

<table>
<thead>
<tr>
<th>Countries that monitor external gamma dose rates</th>
<th>11 members (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, Sweden)</th>
<th>2 observers (Netherlands, Romania)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries that report to monitor the gamma spectrum</td>
<td>4 members (Denmark, Estonia, Germany, Poland)</td>
<td>Continuous in all 11 member states and 2 observer states. (Russia also has stations that measure every 3 hours or daily.)</td>
</tr>
<tr>
<td>Measurement frequency for dose rate</td>
<td>Ranges from 4 (Iceland) to approx. 1800 (Germany). (Average density of stations ranges from 1 per 200 km2 (Germany) to 1 per 26 000 km2 (Iceland).)</td>
<td></td>
</tr>
</tbody>
</table>
3.2.2. Air

All member states and both of the participating observer states report to be monitoring air. All of these states measure the gamma spectrum/cesium-137, but the majority also monitor other radionuclides. These additional radioactivity measurements are gross alpha, gross beta and iodine-131, polonium-210, lead-210, strontium-90, the alpha spectrum, krypton-85, and/or xenon-133/-135.

In countries that measure different types of radionuclides, the number of air sampling stations used for the different kinds of analyses can vary with regard to radionuclides; for example, in Poland, the gamma spectrum is analysed at 12 stations, while the gross alpha and gross beta measurements are performed at 7 stations. Most countries perform weekly measurements, but a few countries have less frequent analyses for some of the radionuclides. The air flow rate also varies among different countries.

Air monitoring in the CBSS members states has also already been harmonised to large extent and is shared through both the CBSS.

Table 3.2. Key summary of air monitoring in member and observer states from which the Working Group was able to acquire information (eleven members and two observers).

| Countries that monitor air | 11 member states (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, Sweden)  
2 observer states (Netherlands, Romania) |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Countries that report to monitor... | 11 member states (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, Sweden)  
2 observer states (Netherlands, Romania) |
| ...the gamma spectrum/cesium-137 (and Be-7) | 11 member states (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, Sweden)  
2 observer states (Netherlands, Romania) |
| ...gross alpha | 2 member states (Germany, Poland)  
1 observer state (Netherlands) |
| ...gross beta | 4 members (Finland, Germany, Poland, Russia)  
2 observers (Netherlands, Romania) |
| ...alpha spectrum | 1 member (Germany)  
2 observers (Netherlands, Romania) |
| ...Pb-210 | 1 member (Finland) |
| ...Po-210 | 1 member (Finland) |
| ...Sr-90 | 2 members (Germany, Russia) |
| ...Kr-85 and Xe-133/-135 | 1 member (Germany) |
| ...iodine-131 | 3 members (Denmark, Germany, Russia) |
| ...plutonium-238,-239+240 | 1 member (Russia) |
| Number of stations for the gamma spectrum/cesium-137 | Ranges from 1 (Iceland) to 52 (Germany, Russia). (The average station density relative to land area ranges from 2800 km2 per station (Netherlands) to 100 000 km2 per station (Iceland).) |
| Measurement frequency of the gamma spectrum/cesium-137 | Is performed weekly in most countries (however, the full range is from daily to monthly). |
Figure 3.2. CBSS member states monitoring air, based on the information collected in the survey.
3.2.3. Deposition

Eight of the eleven reviewed member states perform monitoring of deposition, as well as both of the reviewed observer states. Seven of these members plus both observers perform gamma spectrometry. Furthermore, four members and both observers measure gross beta, and five member states measure strontium-90. A couple of the member states also measure additional nuclides (see table 3.3).

Atmospheric deposition here refers to the settling of particles from the atmospheric environment to surfaces, such as plants or soil. This occurs via two processes: wet deposition (via precipitation) and dry deposition (via the settling of dry particulates). Dry deposition can be sampled separately using textile filters. Some countries use precipitation collectors only, while others use textile filters in addition. It will be important for data comparability that the dry deposition also is analysed if no precipitation has occurred since the last sampling, either by measuring dry deposition separately, or by rinsing the precipitation collector. It can be assumed that all monitoring countries include both wet and dry deposition, but this has not yet been verified.

The deposition data is reported in both Bq/m² and in Bq/l. A couple of countries are reporting in Bq/m² per month or per day. Definition of the sampling period would be necessary in order to appropriately interpret the data.

The number of sampling sites varies among the reviewed countries, ranging from 1 to 410 sites in the countries that do monitor deposition. (Relative to land area, the average density of sampling sites ranges from 3600 km² per site to 42 000 km² per site.)

The measurement frequency of deposition varies quite a bit, both among the different countries and among the different radionuclides analysed. Gamma spectrum/cesium-137 analysis is most commonly performed once per month, but it ranges from weekly to once per year.

### Table 3.3. Key summary of deposition monitoring in member and observer states from which the Working Group was able to acquire information (eleven members and two observers).

<table>
<thead>
<tr>
<th>Countries that monitor deposition</th>
<th>8 member states (Denmark, Finland, Germany, Iceland, Lithuania, Poland, Russia, Sweden)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 observer states (Netherlands, Romania)</td>
</tr>
<tr>
<td>Countries that report to monitor...</td>
<td></td>
</tr>
<tr>
<td>...gamma spectrum/cesium-137</td>
<td>7 members (Denmark, Finland, Germany, Iceland, Poland, Russia, Sweden)</td>
</tr>
<tr>
<td>(and Be-7)</td>
<td>2 observers (Netherlands, Romania)</td>
</tr>
<tr>
<td>...gross beta</td>
<td>4 members (Germany, Lithuania, Poland, Russia)</td>
</tr>
<tr>
<td>...strontium-90</td>
<td>5 members (Denmark, Finland, Germany, Poland, Russia)</td>
</tr>
<tr>
<td>...tritium</td>
<td>4 members (Denmark, Finland, Germany, Russia)</td>
</tr>
<tr>
<td></td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>...alpha spectrum</td>
<td>1 member (Germany)</td>
</tr>
<tr>
<td>...gross alpha</td>
<td>1 member (Netherlands)</td>
</tr>
<tr>
<td>...polonium-210</td>
<td>1 member (Netherlands)</td>
</tr>
<tr>
<td>...lead-210</td>
<td>1 member (Netherlands)</td>
</tr>
<tr>
<td>Number of sampling stations for the gamma spectrum/cesium-137</td>
<td>The known number ranges from 1 (Netherlands) to 410 (Russia). (The average density of stations ranges from 3600 km² per site (Denmark) to 42 000 km² per site (Netherlands, Russia).)</td>
</tr>
<tr>
<td>Measurement frequency for the gamma spectrum/cesium-137</td>
<td>Most common is monthly (Finland, Poland, Sweden, Romania, Russia), but it ranges from weekly (Germany, Netherlands) to annually (Denmark).</td>
</tr>
</tbody>
</table>
Figure 3.3. CBSS member states monitoring deposition, based on the information collected in the survey.
3.2.4. Soil

Among the reviewed countries, six member states and 1 observer state are monitoring radioactivity in soil. All of these seven countries monitor gamma spectrum/cesium-137 activity. In addition, some of them also measure strontium-90, gross beta activity, radium-226, actinium-228, and potassium-40. In addition to collecting soil samples, one member state also performs in situ gamma spectrometry of the soil.

Sampling methods are somewhat different, for example with respect to sampling depth and sampling distribution. However, the Working Group does not currently have enough details to establish the full range of variability for the sample preparation methods.

For countries where the total number of sampling sites has been reported, the number of sites ranges from 2 to around 450. (In relation to area, this corresponds to a range from approximately 1 site per 32 000 km² to 1 site per 900 km².)

Soil sampling and measurements are usually performed less frequently than many other sampling media. One country samples and measures gross beta weekly; however, all other countries perform their sampling and analysis between once per year to every 10 years.

Table 3.4. Key summary of soil monitoring in member and observer states from which the Working Group was able to acquire information (eleven members and two observers).

| Countries that monitor soil | 6 members (Denmark, Germany, Latvia, Norway, Poland, Russia)  
|:---------------------------|-------------------------------------------------------------|
| Countries that report to monitor... | 1 observer (Romania)  
| ...gamma spectrum/cesium-137 | 6 members (Denmark, Germany, Latvia, Norway, Poland, Russia)  
| ...strontium-90 | 2 members (Denmark, Germany)  
| ...gross beta | 1 member (Russia)  
| ...radium-226 | 1 member (Poland)  
| ...actinium-228 | 1 member (Poland)  
| ...K-40 | 1 member (Poland)  
| Number of sampling sites | The known number of sites ranges from 2 (Latvia) to approx. 450 (Norway). (The average density ranges from 1 site per 900 km² (Norway) to 1 per 32 000 per km² (Latvia).)  
| Measurement frequency for gamma spectrometry | Varies from 1 per year (Germany, Romania) to every 10 years (Norway).  
| Sample preparation | Known procedures for preparation involves drying the soil (Denmark, Norway, Romania), followed by ashing (Denmark) and sieving (Denmark, Norway). Known soil depth sampled ranges from 5 cm (Romania) to 10 cm (Latvia, Poland). |
Figure 3.4. CBSS member states monitoring soil, based on the information collected in the survey.
3.2.5. Surface freshwater

Ten of the eleven member states monitor surface freshwater, and so do both of the reviewed observer states. All of these twelve countries that monitor surface freshwater are measuring the gamma spectrometry/cesium-137, and six members and one observer are also measuring strontium-90. In addition, some of the countries also analyse gross alpha, gross/residual beta, gross gamma, tritium, radon-222, alpha spectrum, uranium-234/-238, radium-226, and lead-210. Freshwater that is monitored due to its use as drinking water is discussed separately in section 3.2.11.

There is some variation in the sampling strategy regarding what type of water bodies are sampled, as well as to what methods are used. It is reported that at least one country filters the sample before analysis, but it is unknown whether this is the case everywhere. Measurements are reporting using both Bq/m³, mBq/m³, or Bq/l.

The number of sites per country varies from 1 to 47. For gamma spectrometry, the frequency varies from weekly or monthly to every three years, but other types of analysis can have higher and lower frequencies.

Table 3.5. Key summary of surface freshwater monitoring in member and observer states from which the Working Group was able to acquire information (eleven members and two observers)

<table>
<thead>
<tr>
<th>Countries that monitor surface freshwater</th>
<th>10 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russia, Sweden) 2 observers (Netherlands, Romania)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries that report to monitor...</td>
<td>10 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russia, Sweden) 2 observers (Netherlands, Romania)</td>
</tr>
<tr>
<td>...gamma spectrum/cesium-137</td>
<td>10 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russia, Sweden) 2 observers (Netherlands, Romania)</td>
</tr>
<tr>
<td>...strontium-90</td>
<td>6 members (Denmark, Finland, Germany, Lithuania, Poland, Russia) 1 observer (Netherlands)</td>
</tr>
<tr>
<td>...gross alpha</td>
<td>3 members (Germany, Latvia, Sweden) 1 observer (Netherlands)</td>
</tr>
<tr>
<td>...gross beta</td>
<td>5 (Germany, Latvia, Sweden) 2 observers (Netherlands (residual beta), Romania)</td>
</tr>
<tr>
<td>...gross gamma</td>
<td>1 member (Germany)</td>
</tr>
<tr>
<td>...alpha spectrum</td>
<td>1 member (Germany, where gross alpha exceeds 0.5 Bq/l))</td>
</tr>
<tr>
<td>...tritium</td>
<td>3 members (Germany, Latvia, Russia) 1 observer (Netherlands)</td>
</tr>
<tr>
<td>...radon-222</td>
<td>1 member (Latvia)</td>
</tr>
<tr>
<td>...uranium-234/-238</td>
<td>1 member (Sweden)</td>
</tr>
<tr>
<td>...radium-226</td>
<td>1 member (Sweden)</td>
</tr>
<tr>
<td>...lead-210</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>Number of sampling sites</td>
<td>Ranges from 1 (Norway) to 47 (Russia). (Density ranges from 1 site per 2700 km² (Denmark) to 1 site per 390 000 km² (Norway).)</td>
</tr>
<tr>
<td>Measurement frequency for gamma spectrum/cesium-137</td>
<td>Known frequencies range from monthly (Germany, Romania, Russia) (weekly or monthly in the Netherlands) to every 3 years (Norway).</td>
</tr>
<tr>
<td>Type of water body</td>
<td>The known types of water bodies that are sampled are rivers only (Estonia, Germany), both rivers and lakes (Lithuania, Poland, Norway, Russia), and incoming water to water plants (Sweden)</td>
</tr>
</tbody>
</table>
Figure 3.5. CBSS member states monitoring surface freshwater, based on the information collected in the survey.
3.2.6. Freshwater biota

Three member states report to be monitoring freshwater biota. All of these three countries measure gamma/cesium-137 levels, and one also analyses strontium-90. Norway takes samples from approximately 20 lakes once per year to every three years (depending on the lake), while Germany samples up to 42 sites in each state twice per year.

Germany and Poland sample fish only, and Norway samples fish in all of these sampling lakes, and also plankton and bottom feeders in one of the lakes.

3.6. Key summary of freshwater biota monitoring in member and observer states from which the Working Group was able to acquire information (ten members and two observers).

<table>
<thead>
<tr>
<th>Countries that monitor freshwater biota</th>
<th>3 members (Germany, Norway, Poland)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries that report to measure...</td>
<td>3 members (Germany, Norway, Poland)</td>
</tr>
<tr>
<td>...gamma spectrum/cesium-137</td>
<td>3 members (Germany, Norway, Poland)</td>
</tr>
<tr>
<td>...strontium-90</td>
<td>1 member (Germany)</td>
</tr>
<tr>
<td>Number of sampling sites</td>
<td>Ranges from approx. 20 in Norway, 34 in Poland, and a higher, unknown number in Germany, with up to 42 sites per state. (This makes the average density 7500 km2 per site in Poland to 19 000 km2 per site in Norway.)</td>
</tr>
<tr>
<td>Sampling frequency</td>
<td>Ranges from twice per year (Germany, Poland) to every 1-3 years (Norway).</td>
</tr>
<tr>
<td>Biota types sampled</td>
<td>Fish only (Germany, Poland) or fish, plankton and bottom feeders (Norway).</td>
</tr>
</tbody>
</table>

Figure 3.6. CBSS member states monitoring freshwater biota, based on the information collected in the survey.
3.2.7. Freshwater sediments

Five member states monitor radioactivity in freshwater sediments. All of these five members monitor gamma/cesium-137. In addition, one country measures strontium-90, and another measures plutonium-238/-239+240.

The number of sites per country ranges from 1 to several dozen. The measurement frequency ranges from every month to every 4 years. From the information that has currently been collected, it is not clear how much variability exists in the sampling and sample preparation procedures, for example concerning whether all samples are sieved or not.

<table>
<thead>
<tr>
<th>Countries that monitor freshwater sediment</th>
<th>5 members (Germany, Lithuania, Norway, Poland, Russia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries that report to monitor...</td>
<td></td>
</tr>
<tr>
<td>...gamma spectrum/cesium-137</td>
<td>5 members (Germany, Lithuania, Norway, Poland, Russia)</td>
</tr>
<tr>
<td>...strontium-90</td>
<td>1 member (Lithuania)</td>
</tr>
<tr>
<td>...plutonium-238/239+240</td>
<td>1 member (Poland)</td>
</tr>
<tr>
<td>Number of sampling sites</td>
<td>Known number of sites ranges from 1 (Norway, Russia) to 18 (Poland), but Germany has an unknown much higher number, as they are sampling up to 40 in the national programme + up to 20 per state.</td>
</tr>
<tr>
<td>Sampling frequency</td>
<td>Varies between monthly (Russia and some German sites) to every 4 years (Norway).</td>
</tr>
</tbody>
</table>

Figure 3.7. CBSS member states monitoring freshwater sediments, based on the information collected in the survey.
3.2.8. Seawater

All eleven member states are monitoring seawater, as well as one of the two observer states that participated in the survey. Nine of the member states plus the one observer state are measuring gamma/cesium-137. Six of the members and the one observer also measure strontium-90. In addition, some individual countries analyse tritium, technetium-99, plutonium, radium-226, gross gamma, alpha spectrum, neptunium-237, americium-241, polonium-210, and gross alpha, residual beta, and lead-210.

The marine monitoring programmes in the CBSS member states are partly organised through HELCOM and OSPAR (see sections 2.2 and 2.3). All of the countries in the survey except two member states (Norway, Iceland) and both observer states (Netherlands, Romania) are contracting parties in HELCOM. Norway, Iceland and the Netherlands are members of OSPAR, however, along with Denmark, Finland, Germany, and Sweden (who are members of both organisations).

The HELCOM monitoring programme specifies how many sampling sites for each medium should be sampled each year and gives the approximate coordinates of the sampling sites. HELCOM lists annual measurements for obligatory and voluntary radionuclides. The guidelines do not specify other sampling or measurement details, but the countries also report their own sampling details along with the results (e.g. sampling depth and whether the sample was filtered or not). The OSPAR agreement requires different analyses and frequencies for different sites, and also specifies approximate locations for the sampling sites. OSPAR also does not specify common sampling and measurement details. The sampling strategy can therefore still vary some among the participants of these organisations as these details are not specified.

The Euratom recommendation 2000/473 includes a recommendation for monitoring coastal surface water. As a consequence, the CBSS countries must consider the guidelines and recommendations of several international organisations when developing strategies for monitoring in the marine environment.

The number of sites per country ranges from 2 to around 40. Naturally, the number of sampling sites is dependent on the size of the marine areas in the vicinity of each country’s coastline, and in most countries, the number ranges from around 5 to 15.

3.8. Key summary of seawater monitoring in member and observer states from which the Working Group was able to acquire information (eleven members and two observers).

<table>
<thead>
<tr>
<th>Countries that monitor seawater</th>
<th>11 members (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, Sweden)</th>
<th>1 observer (Netherlands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries that report to monitor...</td>
<td>9 members (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Sweden)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>gamma spectrum/cesium-137</td>
<td>6 members (Denmark, Finland, Germany, Lithuania, Norway, Russia)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>strontium-90</td>
<td>3 members (Denmark, Finland, Germany, Lithuania, Norway, Russia)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>technetium-99</td>
<td>2 members (Denmark, Norway)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>tritium</td>
<td>2 members (Norway, Poland)</td>
<td>1 member (Germany)</td>
</tr>
<tr>
<td>plutonium-239/-240</td>
<td>1 member (Denmark)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>radium-226</td>
<td>1 member (Germany)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>neptunium-237</td>
<td>1 member (Germany)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>gross gamma</td>
<td>1 member (Germany)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>alpha spectrum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gross alpha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>residual beta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>americium-241</td>
<td></td>
<td></td>
</tr>
<tr>
<td>polonium-210</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lead-210</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of sampling sites for gamma spectrum analysis</td>
<td>Ranges from 2 (Latvia) to 40 (Germany).</td>
<td></td>
</tr>
</tbody>
</table>
Sampling frequency for gamma spectrum/cesium-137

Ranges from monthly/quarterly (Netherlands) or monthly/yearly (Germany) to once per year (Estonia, Finland, Latvia, Poland)

Sampling depth

Known sampling depth is from either surface only (Poland) or both surface and near bottom (Latvia, Lithuania, Norway).

Figure 3.8. CBSS member states monitoring seawater, based on the information collected in the survey.
3.2.9. Marine biota

Nine of the ten member states from which the Working Group acquired information report to be monitoring marine biota. None of the reviewed observer states report to be monitoring marine biota. All of these nine members that include marine organisms in their programme are measuring gamma spectrum/cesium-137. Additional radionuclides that are measured in a few of these countries are technetium-99, polonium-210, strontium-90, the alpha spectrum, plutonium-239+240, and radium-226. (Please note that the different biota types in some cases are analysed for different radionuclides.)

Both the HELCOM programme and the OSPAR programme include sampling of marine biota, and both require samples for three biota categories: fish, aquatic plants, and benthic animals (only molluscs in OSPAR). HELCOM requires gamma spectrum analysis in all samples, and on a voluntary basis they also ask for strontium-90 and naturally occurring radionuclides in fish, as well as technetium-99, plutonium-239+240, and americium-241 in aquatic plants and benthic animals. OSPAR’s requirements vary according to different sites, but they include the gamma spectrum/cesium-137 (and plutonium-239+240 in some sites) in fish, gamma spectrum/cesium-137 and/or technetium-99 in seaweed, and gamma spectrum/cesium-137 and/or Pu-239+240 in molluscs.

Which species are sampled for the different biota types of course varies by location, since they occupy different habitats.

The number of sites varies, but this number is also partly directed by the HELCOM and OSPAR and the size of each country’s coastline, and also vary with the different biota types. For fish, the number of sites ranges from 2 to 20-40 for fish, with generally the same or fewer for benthic animals and seaweed. Samples are in most cases collected and analysed once per year.

3.9. Key summary of marine biota monitoring in member and observer states from which the Working Group was able to acquire information (ten members and two observers).

<table>
<thead>
<tr>
<th>Countries that monitor marine biota</th>
<th>9 members (Denmark, Estonia, Finland, Germany, Iceland, Lithuania, Norway, Poland, Sweden)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries that report to monitor...</td>
<td></td>
</tr>
<tr>
<td>...gamma spectrum/cesium-137</td>
<td>9 members (Denmark, Estonia, Finland, Germany, Iceland, Lithuania, Norway, Poland, Sweden)</td>
</tr>
<tr>
<td>...strontium-90</td>
<td>2 members (Germany, Lithuania)</td>
</tr>
<tr>
<td>...technetium-99</td>
<td>2 members (Denmark, Norway)</td>
</tr>
<tr>
<td>...polonium-210</td>
<td>2 members (Denmark, Norway)</td>
</tr>
<tr>
<td>...alpha spectrum</td>
<td>1 member (Germany)</td>
</tr>
<tr>
<td>...plutonium-239+240</td>
<td>1 member (Norway)</td>
</tr>
<tr>
<td>...radium-226</td>
<td>1 member (Poland)</td>
</tr>
<tr>
<td>Type of biota sampled</td>
<td>Fish only (Poland, Sweden), seaweed only (Lithuania), fish + seaweed (Estonia, Iceland), or fish + seaweed + benthic animals (Denmark, Finland, Germany, Norway).</td>
</tr>
<tr>
<td>Number of sites</td>
<td>For fish: Ranges from 2 (Estonia) to 20-40 (Norway).</td>
</tr>
<tr>
<td></td>
<td>For seaweed: Ranges from 1 (Lithuania) to 13 (Norway).</td>
</tr>
<tr>
<td></td>
<td>For benthic animals: Ranges from 1 (Denmark) to 20-40 (Norway)</td>
</tr>
<tr>
<td>Sampling frequency</td>
<td>Once per year for most countries (but twice per year in Germany, 4 times per year for seaweed in Iceland and Denmark)</td>
</tr>
</tbody>
</table>
Figure 3.9. CBSS member states monitoring marine biota, based on the information collected in the survey.
3.2.10. Marine sediments

Ten out of the eleven reviewed member states, but none of the observers, are monitoring marine sediments. All of these ten members are monitoring gamma spectrum/cesium-137. In addition, two of them measure the strontium-90 in the sediments, and two analyse plutonium isotopes. Finally, one member state also measures potassium-40, and another analyses the radium-226 levels.

HELCOM requires analysis of cesium-137, potassium-40 and the other gamma emitters in the spectrum in their monitoring programme, with strontium-90, plutonium-239+240 (and -238), and natural radionuclides listed as voluntary. OSPAR’s programme does not include sediment monitoring.

When it comes to sampling procedure, the depth of the sample core can vary between the countries. For optimal comparability, it would be beneficial to harmonise some aspects of the sediment sampling procedures.

The number of sites varies from 1 to 20, but this is partly related to the HELCOM’s requirements and the length of the country’s coastline.

Most countries sample and analyse sediments once per year, but as frequent as four times per year in Lithuania. Norway rotates sampling so that it samples from about one-third of the sites each year. Sweden samples annually for four sites, but every five year in the remaining 16 sites.

<table>
<thead>
<tr>
<th>Countries that monitor marine sediments</th>
<th>10 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russia, Sweden)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries that report to monitor…</td>
<td></td>
</tr>
<tr>
<td>…gamma spectrum/cesium-137</td>
<td>10 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russia, Sweden)</td>
</tr>
<tr>
<td>…strontium-90</td>
<td>2 members (Lithuania, Poland)</td>
</tr>
<tr>
<td>…plutonium-239+240 (and -238)</td>
<td>2 members (Norway, Poland)</td>
</tr>
<tr>
<td>…radium-226</td>
<td>1 member (Poland)</td>
</tr>
<tr>
<td>…potassium-40</td>
<td>1 member (Finland)</td>
</tr>
<tr>
<td>Number of sampling sites for gamma spec-trum/cesium-137</td>
<td>Ranges from 1 (Estonia) to 20 (Sweden)</td>
</tr>
<tr>
<td>Sampling frequency</td>
<td>Once per year in most countries. (Lithuania samples 4 times/year, Norway every 3 years, and Sweden samples some sites annually, but most sites every 5 years.)</td>
</tr>
</tbody>
</table>
Figure 3.10. CBSS member states monitoring marine sediments, based on the information collected in the survey.
3.2.11. Drinking water (and ground water)

Eight of the ten member states from which the Working Group was able to collect information and both reviewed observer states are monitoring drinking water in one form or another. Out of these ten reviewed countries that do monitoring drinking water, seven members and one observer measure the gamma spectrum, six members analyse strontium-90, and seven members and one observer measure tritium in the water. Three members and one observer measure the gross alpha activity, while three member states and two observer states analyse the gross beta content. Additionally, individual countries also measure radium-226/-228, radium-226, and uranium-234/-238.

The types of drinking water sources that are monitored can vary among the countries, however. The types of samples reported in the survey are taken from the following types of water sources: raw ground water only; raw lake water and ground water; tap water; raw and purified water from plants plus drinking water from groundwater sources; private wells plus public water supplies; and purified lake water from water plants.

The number of sampling sites varies from country to country, ranging from four to approximately 200. Sampling and analysis frequencies vary as well. Sampling is performed daily in Estonia and continuously (or randomly, depending on the site) in Germany, and analysis frequency also varies by analysis method. For gamma spectrometry, the measurement frequency ranges from monthly to once per year. For gross beta, analysis frequency ranges from daily to twice per year. Most countries perform measurements two to four times per year.

### Table 3.11. Drinking water (and/or ground water) in member and observer states from which the Working Group was able to acquire information (ten members and two observers).

<table>
<thead>
<tr>
<th>Countries that monitor drinking water</th>
<th>8 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden)</th>
<th>2 observers (Netherlands, Romania)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Countries that report to monitor...</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...gamma spectrum/cesium-137</td>
<td>7 members (Denmark, Estonia, Finland, Germany, Latvia, Poland, Sweden)</td>
<td>1 observer (Romania)</td>
</tr>
<tr>
<td>...strontium-90</td>
<td>6 members (Denmark, Estonia, Finalnd, Germany, Poland, Sweden)</td>
<td></td>
</tr>
<tr>
<td>...tritium</td>
<td>7 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Sweden)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>...radium-226/-228</td>
<td>2 members (Estonia, Sweden (radium-226 only))</td>
<td></td>
</tr>
<tr>
<td>...alpha spectrum</td>
<td>1 member (Germany)</td>
<td></td>
</tr>
<tr>
<td>...gross alpha</td>
<td>3 members (Latvia, Lithuania, Sweden)</td>
<td>1 observer (Netherlands)</td>
</tr>
<tr>
<td>...gross beta</td>
<td>3 members (Latvia, Lithuania, Sweden)</td>
<td>2 observers (Netherlands, Romania)</td>
</tr>
<tr>
<td>...radon-222</td>
<td>1 member (Latvia)</td>
<td></td>
</tr>
<tr>
<td>...uranium-234/-238</td>
<td>1 member (Sweden)</td>
<td></td>
</tr>
<tr>
<td><strong>Number of sites</strong></td>
<td>Ranges from 2 (Estonia) to 200 (Netherlands). (Average density ranges from 200 km2 per site (Netherlands) to 75 000 km2 per site (Sweden).)</td>
<td></td>
</tr>
<tr>
<td><strong>Analysis frequency for gamma spectrum/cesium-137</strong></td>
<td>Most countries measure two or four times per year (except monthly in Romania (and one site in Lithuania), once per year in Denmark, and 1-27 times per year in the Netherlands).</td>
<td></td>
</tr>
</tbody>
</table>
Type of water source sampled

Known sources are either only raw ground water (Denmark, Romania), only tap water/treated water supply (Estonia, Finland, Latvia, Sweden), or both (Germany, Lithuania)

Figure 3.11. CBSS member states monitoring drinking water and/or ground water, based on the information collected in the survey.
3.2.12. Milk

From the information the Working Group was able to collect, ten of the member states and one of the observer states monitor radioactivity in milk, and all of these countries perform gamma spectrum analysis. Nine members also measure strontium-90 in milk; two measure potassium-40; and one analyses both gross alpha and gross beta.

Euratom recommendation 2000/473 recommends that the Euratom members measure cesium-137, strontium-90, and potassium-40 (in the sparse network only) in milk collected from dairies. The recommended measurement frequency is monthly for the sparse network and quarterly for the dense network.

The number of sampling sites is generally around 5-10 per country, but the full range for the known number of sites varies from 3 to 34. (The Netherlands report monitoring approximately 75 samples per month; however, it is not known whether these are taken at different sites.) Analysis is in most cases performed four times per year, but a few countries perform the analysis more frequently. Norway performs measurements only during the grazing season (June to September).

Table 3.12. Key summary of milk monitoring in member and observer states from which the Working Group was able to acquire information (ten members and two observers).

<table>
<thead>
<tr>
<th>Countries that monitor milk</th>
<th>10 members (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Sweden)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 observer (Netherlands)</td>
<td></td>
</tr>
<tr>
<td>Countries that report to monitor...</td>
<td></td>
</tr>
<tr>
<td>...gamma spectrum/cesium-137</td>
<td>10 members (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Sweden)</td>
</tr>
<tr>
<td>1 observer (Netherlands)</td>
<td></td>
</tr>
<tr>
<td>...strontium-90</td>
<td>9 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Sweden)</td>
</tr>
<tr>
<td>...potassium-40</td>
<td>2 members (Estonia, Lithuania)</td>
</tr>
<tr>
<td>...gross alpha</td>
<td>1 member (Lithuania)</td>
</tr>
<tr>
<td>...gross beta</td>
<td>1 member (Lithuania)</td>
</tr>
<tr>
<td>Number of sites for gamma spectrum/cesium-137</td>
<td>Known number of sites ranges from 3 (Estonia, Iceland, Latvia) to 34 (Poland). The number in Germany is unknown, but in all likelihood higher, with up to 21 sites per state. (The average known density ranges from 5400 km2 per site (Denmark) to 90 000 km2 per site (Sweden).)</td>
</tr>
<tr>
<td>Analysis frequency</td>
<td>Analysis most commonly takes place 4 times per year, but also takes place monthly in some places (Germany, Iceland, one site in Lithuania), or weekly, but during the summer only (Norway).</td>
</tr>
<tr>
<td>Sample type</td>
<td>Where sample types are described, most countries report sampling milk from dairies only (Germany also samples other dairy products, incl. imported cheese, Iceland samples powdered milk as well as fresh milk).</td>
</tr>
</tbody>
</table>
Figure 3.12. CBSS member states monitoring milk, based on the information collected in the survey.
3.2.13. Food products

In addition to (or instead of) monitoring mixed diet, almost all countries also monitor radioactivity levels in specific food products. The reasons for choosing to monitoring a particular food product may vary; for example, reasons can include that it is very common in the diet (e.g. pork, potatoes), that the product is particularly exposed to elevated radioactivity levels (e.g. wild foods such as mushrooms, berries, reindeer meat), or that the target consumer is particularly sensitive (as with infant foods and milk (although milk is in a separate category in this report)). Results from food monitoring are also used to demonstrate that the food is safe.

All ten of the member states for which the Working Group acquired information, as well as one of the observer states, report that they are monitoring other food products of some kind, and all of these are analysing the gamma spectrum. Six of the members are also monitoring strontium-90 levels. In addition, two member states are measuring potassium-40, and one is monitoring gross alpha and gross beta levels. Which products are selected for monitoring differs among all of these countries, although as a general summary, one country monitors infant food, eight countries monitor meat and/or other foods of animal origin, six countries monitor vegetables, grains and/or other foods of plant origin, and four countries are monitoring mushrooms. Some countries specify the sampling of wild foods (berries, mushrooms, fish and/or game). It also seems that some monitoring programmes are focusing on the commonly consumed foodstuffs, while others focus on high-risk products or both.

The number of sites varies widely and also varies for the different food products.

Table 3.13. Key summary of monitoring of food products in member and observer states from which the Working Group was able to acquire information (ten members and two observers).

| Countries that monitor other food products | 10 members (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Sweden) 1 observer (Netherlands) |
| Countries that report to monitor... | 10 members (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Sweden) 1 observer (Netherlands) |
| ...gamma spectrum/cesium-137 | 10 members (Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Sweden) 1 observer (Netherlands) |
| ...strontium-90 | 6 members (Denmark, Finland, Germany, Latvia, Lithuania, Poland) |
| ...potassium-40 | 2 members (Estonia, Lithuania) |
| ...gross alpha | 1 member (Lithuania) |
| ...gross beta | 1 member (Lithuania) |
| Number of sites | This varies greatly both between countries and the types of food sampled. (See table for details) |
| Sampling frequency | This varies widely according to what type of food is sampled, but vegetable crops and meat from domestic animals are often sampled once per year in connection with harvesting or slaughter. Infant food is sampled monthly (Germany) |
| Sample type | Details of which types of food are sampled is not available for all countries. From the countries where details are available, it can be summarised that 1 monitors infant food (Germany), 8 monitor meat and/or other foods of animal origin (Estonia, Germany, Iceland, Latvia Lithuania, Norway, Sweden, Netherlands), 6 monitor vegetables, grains and/or other foods of plant origin (Estonia, Germany, Latvia, Lithuania, Norway, Netherlands), and 4 monitor mushrooms (Estonia, Latvia, Lithuania, Norway). Some specify the sampling of wild origin (in reference to berries, mushrooms, fish and/or game). |
Figure 3.13. CBSS member states monitoring food products, based on the information collected in the survey.
3.2.14. Mixed diet

This sampling medium is intended to indicate the average public exposure to radioactivity in the diet through the sampling of complete meals from hospitals, canteens, or similar, or by sampling individual ingredients and combining them in a way that represents that average diet in the region. Euratom recommendation 2000/473 recommends that member states monitor complete meals and individual ingredients (along with the composition of the diet) where appropriate, taking into account regional variations, and analyse the gamma spectrum and strontium-90 at least quarterly and report the results in Bq/d.p. (becquerel per person per day).

Eight of the ten member states for which the Working Group collected information, but none of the observers, monitor mixed diet in one form or another according to the survey, and all of these eight measure both gamma spectrum/cesium-137 and strontium-90. In addition, three member states measure potassium-40, and one also analyses gross alpha and gross beta in the samples.

The number of sampling sites varies between one and nine, and the sampling frequency ranges from once per month to once per year. The countries use Bq/d.p., Bq/sample or Bq/kg as the reporting unit for this medium.

The sampling details vary somewhat, but most of the reviewed members that monitor mixed diets sample complete meals from hospitals or other large-scale kitchens. In one member state, the ingredients are collected from the market and mixed to represent the average diet. However, this variability should not have a significant impact on the results as long as the samples are representative of the diet.

Table 3.14. Key summary of mixed diet monitoring in member and observer states from which the Working Group was able to acquire information (ten members and two observers).

| Countries that monitor mixed diet | 8 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden) |
| Countries that report to monitor... | 8 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden) |
| ...gamma spectrum/cesium-137 | 8 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden) |
| ...strontium-90 | 8 members (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden) |
| ...potassium-40 | 3 members (Estonia, Lithuania, Sweden) |
| ...gross alpha | 1 member (Lithuania) |
| ...gross beta | 1 member (Lithuania) |
| Number of sites | The known number of sites ranges from 1 (Latvia, Lithuania, Poland) to 9 (Denmark). (The known average density ranges from 4800 km2 per site (Denmark) to 310 000 km2 per site (Poland).) |
| Sampling and analysis frequency | The known frequency ranges from monthly (Lithuania) to once per year (Denmark, Finland). |
| Sampling method | The sample type and method varies, and not all of the details are known. The food is in most cases collected from hospitals or other large kitchens, but Denmark collects ingredients from the market and mixes it to represent average diet. Known sampling period ranges from kitchens ranges from 1 day to 1 week. Some specify to include beverages, but it is unclear whether all countries do this. |
Figure 3.14. CBSS member states monitoring mixed diet, based on the information collected in the survey.
3.2.15. Indicator biota

The species that are included in this category are organisms that are usually not used directly for human consumption, but are used to indicate radioactivity levels elsewhere in the environment or in other parts of the food chain. Three member states and one observer state report to be monitoring one or more types of indicator species. Denmark and Romania monitor grass, and Germany monitors plants not used for food or animal feed. Norway monitors plants and lichen species, and also several different species of wild animals. All four of these countries measure gamma spectrum/cesium-137. In addition, the observer state measures gross beta activity, and one member state measures strontium-90.

Grass is sampled weekly in Denmark and Romania, with a delay for gamma spectrum analysis. Measurements are made yearly in Germany and Norway (except for earthworms). The number of sampling sites ranges from one to as high as 50.

Table 3.15. Key summary of indicator biota monitoring in member and observer states from which the Working Group was to acquire information (ten members and two observers).

<table>
<thead>
<tr>
<th>Countries that monitor indicator biota</th>
<th>3 members (Denmark, Germany, Norway)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 observer (Romania)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Countries that report to monitor...</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>...gamma spectrum/cesium-137</td>
<td>3 members (Denmark, Germany, Norway)</td>
</tr>
<tr>
<td></td>
<td>1 observer (Romania)</td>
</tr>
<tr>
<td>...strontium-90</td>
<td>1 member (Denmark)</td>
</tr>
<tr>
<td>...gross beta</td>
<td>1 observer (Romania)</td>
</tr>
</tbody>
</table>

| Number of sites                       | Ranges from 1 (Denmark) to up to 50 (Germany). |
| Sampling and measurement frequency (for gamma spectrum) | Sampling frequency ranges from weekly for grass (Denmark, Romania) to every 5 years for earthworms (Norway). Measurements are made annually except every 5 years in earthworms (Norway). |
| Sample types                          | The known sampled organisms are: Denmark and Romania: grass |
|                                       | Germany: indicator plants not used for food or feed in Norway: plants, lichen, predator animals, woodcock, earthworms, and small rodents. |

Figure 3.15. CBSS member states monitoring indicator biota, based on the information collected in the survey.
3.2.16. Sewage

Two of the ten reviewed CBSS members are monitoring the radioactivity levels in sewage. Both Finland and Germany analyse the gamma spectrum, while Germany also measures strontium-90 and the alpha spectrum.

Finland samples and analyses samples of undigested sewage sludge and dewatered sludge quarterly. Germany samples the sewage and sewage sludge continuously or randomly, and it analyses gamma emitters quarterly, while strontium-90 and the alpha spectrum are analysed twice per year.

Finland monitors sewage at one site, while Germany monitors the gamma spectrum up to 10 sites per state (up to two per state for strontium-90 and alpha spectrum).

Table 3.16. Key summary of sewage monitoring in member and observer states from which the Working Group was able to acquire information (ten members and two observers).

<table>
<thead>
<tr>
<th>Countries that monitor sewage</th>
<th>2 members (Finland, Germany)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries that report to monitor...</td>
<td></td>
</tr>
<tr>
<td>...gamma spectrum/cesium-137</td>
<td>2 members (Finland, Germany)</td>
</tr>
<tr>
<td>...strontium-90</td>
<td>1 member (Germany)</td>
</tr>
<tr>
<td>...alpha spectrum</td>
<td>1 member (Germany)</td>
</tr>
<tr>
<td>Number of sites</td>
<td>1 site in Finland; up to 10 per state in Germany for gamma spectrum (2 per state for strontium-90 and alpha spectrum).</td>
</tr>
<tr>
<td>Sampling/measurement frequency</td>
<td>Finland: Sampling and measurement 4 times/year. Germany: Continuous or random sampling, analysis 4 times/year for gamma spectrum, 2 times/year for strontium-90 and alpha.</td>
</tr>
<tr>
<td>Sample type</td>
<td>Finland: undigested sewage sludge, dewatered sludge. Germany: Sewage and sewage sludge.</td>
</tr>
</tbody>
</table>

Figure 3.16. CBSS member states monitoring sewage, based on the information collected in the survey.
4. EVALUATION THE SAMPLING MEDIA’S RELEVANCE FOR HARMONISATION AND DATA SHARING

Some monitoring results might be more useful to the international community than others. For example, one can easily imagine how information about airborne radionuclides, which travel quickly and freely across borders, could be relevant and useful for the neighbouring countries, while the results for other more immobile media might not necessarily be as relevant. If any of the sampling media are not very relevant to other countries, or if they would be very costly or difficult to harmonise, there is a risk that the harmonisation and data sharing process would be overall more costly than beneficial in these cases. In the initial stages of the process, it therefore seems logical to focus on the sampling media that would be the most relevant for data sharing and the most cost-effective for harmonisation.

Below are some criteria that can be used to evaluate the relative costs and benefits associated with the harmonisation and data exchange for the different sampling media. The evaluation can help decide which of the sampling media should be prioritised in the future harmonisation and data sharing process. In such an evaluation, it is worth considering:

- How relevant the information is for estimating doses to the public in other countries
- How relevant the information is to emergency preparedness and response
- How useful the information would be to other countries in the region
- How much it would cost to harmonise the programmes
- The extent of the changes that would be needed in order to harmonise the programmes
- How relevant the information is for evaluating the levels of environmental contamination in the region

Preliminary evaluations of the costs and benefits associated with harmonisation and data sharing for each sampling medium follow below.

4.1. External ambient gamma radiation

Because external ambient gamma dose rates represent ambient gamma radiation from all external sources, and because the instrumentation used is capable of continuous reporting, this sampling medium is highly relevant to estimating doses and to act as a warning system in the case of a radiological emergency.

During the release phase of a nuclear accident, external gamma dose rate measurements will include the contribution of radiation from the plume. In the post-release phase, the external gamma dose rate measurements are mainly attributable to radiation from deposition on the ground. Because external gamma dose rates can provide so much useful data in an emergency situation, it is highly relevant for other countries in the region. The data can be used to estimate doses to the public in both normal and emergency situations, and in the case of emergency preparedness, it can also offer additional important information, such as the movement of the radioactive cloud.

The priority for harmonising of external gamma dose/dose rate monitoring can be rated as high based on its importance and relevance alone; however, external gamma dose rate monitoring is already harmonised to a large extent and the data for all of the countries in our survey is already automatically shared through the CBSS. Some variability does exist in the equipment used and the sampling site density, but this does not significantly affect the comparability of the data.

Because the monitoring of external gamma dose rates are already comparable and shared, there is little need to further harmonise the existing methods.

4.2. Air

Airborne radioactive materials may occur in either gaseous or particulate form, and may originate either directly from discharges to the atmosphere or from the re-suspension of radionuclides deposited onto soil or other surfaces.

Airborne radionuclides is an important source for radionuclides that enter the human body, either directly through inhalation or by being deposited in water or on soil or plants and contaminate the media used for human consumption. However, whether the nuclides can enter the body or lead to exposure is dependent on the nuclide and the particle size. Information about the radioactivity of airborne radioactivity can therefore also be used when estimating doses to the public, and is particularly relevant for estimating doses
received via internal exposure.

The identification of airborne radionuclides and information about their dispersion is relevant information to the international community, as airborne radionuclides disperse in the atmosphere and can travel great distances and across borders. Consequently, sharing information about air is particularly important in an emergency situation. Air are sampled by pumping air through filters and then removing and analysing the filters. The air measurements are not very frequent under normal conditions; however, most countries will increase their measurement frequencies in the case of an emergency.

The air monitoring data from the CBSS members is already shared through the CBSS. There is some variability in the methods used for air measurements; however, this does not significantly affect the comparability of the existing results.

Harmonisation of air monitoring is given high priority based on its importance and relevance; however, the harmonisation and sharing of this sampling medium is already much more developed for this sampling medium than for most other sampling media.

4.3. Deposition

The term deposition includes both wet deposition (through precipitation) and dry deposition, and represents the transfer of radioactive particulates from the atmosphere to the earth’s surface, and consequently to water, soil and the food chains. Radioactive deposition can therefore lead to both external radiation exposure and to internal exposure due to ingestion of radioactive contaminants via the food chain.

Precipitation increases the rate of deposition and therefore plays an important role in determining which areas receive heavy contamination after a release. Contaminated precipitation is created either when radionuclides present in the clouds become incorporated in cloud droplets that then precipitate, or when previously uncontaminated precipitation falls through contaminated air masses. Because precipitation often exhibits relatively local variations, this can cause heterogeneous patterns of contamination. As the particle size affects how far the airborne radionuclides can travel, this will of course also be reflected in the deposited radionuclides. When radioactive deposition occurs through snow or settles on top of snow, it can behave differently than with other types of deposition. During the winter, the deposition accumulates in the snow, which can be moved, piled up, or dumped into the water, and which can create a sudden large release when the snow melts in spring.

Deposition data can be useful for estimating doses to the public, and it is particularly useful in the later phase of an emergency situation for assessing doses and evaluating the consequences of the release. The measurements provide data for mapping the radioactive deposition following a nuclear incident and are therefore important to emergency responses.

The deposition data would be useful to other countries in the region, especially during radiological emergencies, seeing as the airborne radioactive particulates can travel great distances before being deposited and deposition data includes information about where these particulates are settling.

Most of the surveyed countries monitor deposition; however, three of the member states do not. Monitoring and sampling methods also differ somewhat among the countries that are monitoring; for example, not all of them perform gamma spectrum analysis. In order to achieve the maximum benefits from sharing the information, it could be beneficial to harmonise the methods. This harmonisation process is not believed to be very costly or requiring very large changes.

4.4. Soil

In the longer term, soil acts as a reservoir for long-lived radionuclides in the terrestrial environment. The interaction between soil components and radionuclides in large part determines the bioavailability for plants and animals. The soil characteristics therefore have a large effect on the radioactive contamination of the biota. Some radionuclides are more mobile in the environment than others, and can easily be transferred to the food chains. Other, insoluble radionuclides that are less mobile tend to remain in the soil.

Undisturbed natural soils tend to retain more radionuclides for longer than cultivated soil does, in part due to the different physical and chemical properties of the soil and the generally more nutrient-poor conditions in undisturbed soils (which increases the cesium-potassium ratio and in turn increases the relative uptake of cesium). Soil erosion and runoff can redistribute the radionuclides in the contaminated soil across land areas or into water, and fires can release accumulated radionuclides to the atmosphere.

Measurements of radioactivity in soil is also to a large extent related to the transfer of atmospheric radionuclides to the food chains, but unlike the sampling media previously discussed, it also provides information about the accumulation of deposited radionuclides in the terrestrial environment over time. This offers additional insight into the cumulative environmental impact of several or diffuse sources of radioactive material, and can be used to monitor the movement of radioactive material in the environment.
as well. Although soil may not be directly relevant for dose assessments, it is a good indicator for the amount of radionuclides present in the terrestrial environment.

The soil data may be directly relevant for other countries due to the potential for erosion or resuspension, although it can be still also be useful to others for use in developing and verifying models.

About half of the countries in the survey monitor the radioactivity in soil. These countries are using some different sampling and measurements methods, and for optimal data comparability, some harmonisation is needed. However, the costs associated with this are assumed to be moderate.

4.5. Surface freshwater

Radioactive contamination of the surface freshwater systems can be caused by direct deposition of radionuclides to the river and lake surfaces and runoff from the surrounding catchment area. Contaminated runoff can occur either via soil erosion or by dissolved radionuclides that are directly transported by runoff. Radioactivity levels in runoff are mostly low, but it is nonetheless a source of continuous contamination. Temporary increases can also occur during floods.

Radionuclides in surface water can be found in the water phase or associated with suspended particles, and can eventually become incorporated into sediments and biota. Radionuclides can be removed from the water body by the outflow of water or by transfer to the sediment (from which they may be remobilised at a later stage). Adsorption to suspended matter partly depends on the radionuclide element, the composition and concentration of suspended particles, and the water chemistry. In addition, small particles tend to transport radionuclides longer distances than large particles.

Due to the lower volume of water, the dilution factor in freshwater systems is much lower than in marine systems. Furthermore, water in closed lake systems (i.e. lakes with little inflow and outflow of water) typically also have much higher radioactivity concentrations than open freshwater systems.

Radioactivity levels in freshwater has some relevance to dose estimation through the consumption of freshwater fish and shellfish, but this can be estimated more accurately using the direct measurements of the relevant species. (Although, more countries currently monitor surface freshwater than freshwater biota, so in this regard water monitoring has an advantage.) Surface freshwater can also be used for irrigation, and in these cases, monitoring results can be used for the assessment of the public doses from consumption of plant and animal products produces on irrigated land as well. Surface freshwater is also used for drinking water in some areas; however, these cases are evaluated separately in the discussion of drinking water (see section 4.11.).

Almost all of the reviewed countries monitor surface freshwater and perform gamma spectrometry measurements. The sampling details and methods vary to some extent and the type of water bodies that are sampled can vary; however, the harmonisation of the procedures should not cause a big financial burden or very big changes. For the surface freshwater data to be truly comparable, however, additional information would also be necessary, for example characteristics regarding the flow rate and flux. Without this information, it could be hard to interpret and compare the data. Radioactivity in open freshwater systems still can be relevant to other countries due to their transport of these materials into the marine environment or in rivers that run across national borders.

4.6. Freshwater biota

Radionuclides that make their way into rivers and lakes can eventually become incorporated into the organisms that inhabit them.

Fish can in some cases accumulate of lot of radionuclides and may contain high concentrations of radionuclides even in water with relatively low radioactivity levels. This is sometimes the case with radioactive cesium contamination. Organisms accumulate cesium because this element is chemically similar to potassium and therefore is taken up via the same channels. A low potassium concentration in the water therefore increases the relative uptake of radiocesium in the organisms, while high potassium levels decrease the relative radiocesium uptake. The organisms that live in closed lake systems also typically has much higher radioactivity concentrations than the organisms found in open freshwater systems. Bioaccumulation of radiocesium in fish can vary significantly between different species, and predatory species and larger individuals tend to accumulate higher levels than non-predatory and smaller fish. Another important isotope, strontium-90, is chemically similar to calcium and is similarly affected by the amount of calcium in the water.

Freshwater fish is an important food source in many areas, and the consumption of freshwater fish is a significant part of the dose received from the aquatic environment. Monitoring of freshwater biota is therefore highly relevant to estimating doses to the public, and can also serve as a basis to control or offer advice about the safe consumption of contaminated freshwater fish and shellfish.

Only three countries are currently monitoring freshwater biota, so while the methods used for the monitoring in these countries are similar, there is not much information that is currently being collected in the CBSS region.
4.7. Freshwater sediments

Over time, radionuclides in the water tend to settle into the sediments. This process removes much of the radio-active contamination from the water, but stores it in the sediments, which can act then as a sink for long-term radionuclide release. Sediments have a particularly large influence on the water radioactivity level in closed lake systems. The top sediment layer can act as a source for remobilisation or transfer to the food chain via the bottom-feeding species. Radioactive sediment eventually gets buried by new sediment, but this rate is naturally dependent on the sedimentation rate. Any large disruption of the sediments, however, would be capable of releasing a lot of previously buried radiocontaminated particles at once.

Some radionuclides are more likely to adsorb to sediments than others (for example, cesium-137 has a much higher tendency to bind to sediment particles than strontium-90). The level of adsorption in turn influences its degree of transport through the freshwater system and bioaccumulation in the food chains.

Freshwater sediment is monitored in only four countries. The sampling frequencies do vary greatly, however the measurement methods used are very similar. However, taking into account the georgraphically restrained nature of the freshwater environments, sharing of freshwater sediment data probably has limited direct international relevance.

4.8. Seawater

Radioactive contamination of seawater can be caused by discharges from industry and other facilities, for example nuclear facilities and the offshore oil and gas industry, and radionuclides can also enter the sea via atmospheric deposition and inputs from freshwater systems. Radionuclides discharged into the marine environment can mainly lead to exposure through ingestion of contaminated seafood.

Sampling and measurement of seawater can have some relevance for estimating doses to the public through sea food under normal conditions. Radionuclides move through international waters with the currents, affecting several countries, and these would also be helpful to modelling dispersion patterns. Because of the water’s relatively slow movement, seawater monitoring might have limited relevance to assessment of the public doses during an emergency situation, unless it is a matter of direct radioactive releases to the sea.

Most countries already monitor seawater, and marine monitoring programmes are to some extent harmonised through international organisations, most notably HELCOM and OSPAR. However, there are still differences in the methods used both between and within these organisations, and furthermore, these organisations do not include all CBSS member and observer states. In order to achieve full data comparability some harmonisation would therefore be necessary.

4.9. Marine biota

Radioactivity in marine biota is relevant for estimating the doses to the public caused by the intake of seafood, but marine organisms can also be used as marine indicators of the radionuclide content in the water. Some species are highly mobile (many species of fish and crustaceans), others are not (molluscs and seaweed). Considering that most of the countries in the region are situated around the Baltic Sea, data on the radioactivity levels in marine biota can be of relevance to the other countries in the region, especially with regard to the more mobile species and indicator organisms. Seaweed can also be used as fertilisers and thereby represent a transfer to the terrestrial environment. There is also international interest in radioactivity levels in marine biota due to the import and export of fish and shellfish.

Due to the relatively slow movement of water and biota and rate of bioaccumulation, biota monitoring might have limited relevance in the release phase of an emergency situation, unless it is a matter of direct discharges to the sea.

Most countries already monitor marine biota as part of their marine monitoring programmes, which are to some extent harmonised through international agreements. However, none of the agreements include all CBSS states, and there is still some variability among the different methods and strategies for monitoring marine biota.

4.10. Marine sediments

Many of the radionuclides that are discharged into water do not stay dissolved in the water; instead, they tend to become adsorbed to particulate material, which with time accumulates as bottom sediment. This means that marine sediments may serve as indicators for the radionuclide pollution levels in the sea and uptake in the bottom-feeding biota. Bottom sediments can be used, therefore, as indicators of contamination due to past discharges, with the upper layers of sediment representing the most recent contamination. Sediments may also be deposited onto low-lying grazing land during periods of flooding or unusually high tides. Sediment is also a part of the marine food chains, as many organisms live in the sediment or ingest sediments.
The monitoring data for marine sediments provide information about local pollution levels and can in some cases be used in the estimation or indicator of doses to the public. However, the information has limited use for emergency response, as the sedimentation process is usually slow, and the radioactivity levels in seawater or biota would offer more useful information in that scenario. Ultimately, the discussion of whether marine sediment monitoring is important depends on the objective of the monitoring programme: for dose rate assessments, monitoring of marine biota is more important, while if the objective involves having a complete overview of the situation in the marine environment (e.g. for assessments of transfer and transport), sediments play an important role.

Most countries already monitor marine sediments, the monitoring is partly harmonised through HELCOM. The OSPAR programme does not include sediment monitoring. Some harmonisation would therefore be needed in order to be able to share fully comparable data.

4.11. Drinking water (and ground water)

Both surface freshwater and ground water sources are used as drinking water. Monitoring of radioactivity in drinking water can be performed either by sampling at the source, the tap, or somewhere in between in the water treatment/distribution systems.

For surface freshwater sources, radioactive contamination can occur by direct deposition in the freshwater system or contamination runoff from nearby land areas, although the radionuclide concentrations in drinking water from surface sources is generally very low. Some of the radionuclides deposited in the soil can also be transferred to the groundwater. The level of contamination is typically low, however, and the migration rate from soil to groundwater is also usually slow. Because of this, and also because the groundwater residence time tends to be very long, the short-lived radionuclides are generally not present in groundwater by the time it is used for drinking water. Since groundwater sources are not subject to direct deposition, radioactive contamination from anthropogenic releases is in most cases even lower in groundwater than in surface freshwater systems.

Drinking water can also be affected by naturally occurring radionuclides, however. This is especially the case for groundwater sources that are in contact with bedrock, which can release significant levels of naturally occurring radionuclides – particularly radon – to the water. Radon concentrations in private drilled wells can in some areas be very high, but private wells are often unregulated and the concentrations often never measured.

Drinking water is monitored because of its vital importance for humans, and radioactivity levels in drinking water are naturally relevant to estimating annual doses to the public. It is also relevant for estimating internal doses in case of radiological emergencies, especially emergencies related to airborne contamination.

Where groundwater is a major source of drinking water, as no rapid changes in the radionuclide concentration would be expected during routine discharges. In areas contaminated by long-lived radionuclides, analysis of annual samples would normally be sufficient. Where drinking water is taken from a lake, pond or river located close to a facility, more frequent sampling may be required, especially in emergency situations. Spot samples are usually taken a few times per year and analysed individually. In order to make the data comparable, some harmonisation would be necessary, both with regard to sampling and measurement methods (especially which nuclides are analysed).

4.12. Milk

Consumption of milk and dairy products has been shown to be one of the most important pathways for uptake of radionuclides from the environment to humans. There might be also a need to control and limit use of fresh milk during emergencies. Radioactivity (mainly iodine isotopes) in milk can represent one of the most significant dose contributions immediately following a nuclear accident. Radioactive iodine is almost completely absorbed in the animal gut and is very quickly transferred to the milk. Fresh milk also makes it onto the market very quickly. The overall time from iodine is deposited on the pastures until the contaminated milk is sold and consumed by humans can therefore be very brief. The quick transfer of iodine-131 from pastures to humans, coupled with the short half life of iodine-131 (8 days), makes immediate action necessary if an emergency situation occurs. Strontium-90 mimics calcium is can therefore also be absorbed in large quantities in lactating animals and transferred to the milk. Milk is an especially important calcium source for children and young animals due to its importance in developing the skeleton, and much of the strontium from the milk can therefore become incorporated in the bones of the young.

Restricting the access of contaminated milk to the market is also considered especially important it can be consumed in large quantities and because young children, who are particularly sensitive to exposure, can consume relatively large amounts of milk. Furthermore, milk is a very good indicator of the contamination of animal products in general. Due to its short half-life, iodine-131 in milk should be analysed frequently, depending on local agricultural practices (e.g. monthly).

In a normal situation, the radioactivity levels in the milk in one country would not necessarily be relevant to other countries in the region, especially taking account the different practices of the animal husbandry. The monitoring methods used in different countries are relatively consistent, and the samples are often
collected from the local dairies. While monitoring levels in store-bought milk is not a problem in itself, analysing the milk from regional dairies would be more useful in emergency preparedness situations, as this also makes it possible to determine which regions of the country the milk production is contaminated. In the case of an emergency, it would be useful to know the levels of radioactivity in at least the neighbouring areas, in order to plan countermeasures and inform the population.

Milk is monitored in almost all of the reviewed countries, and while there are still some details that should be harmonised to achieve optimal comparability, it is assumed that only small changes would be necessary for full harmonisation.

4.13. Food products

In the initial stage after a radioactive release to the atmosphere, direct deposition onto the leaves is the major pathway of plant contamination. In the longer term, continuing uptake of radionuclides from the soil into plants and mushrooms is the major contributor to dose, and via these channels, high radioactivity levels can be sustained for very many years.

The radioactive contamination in plants and mushrooms can enter the human diet directly through edible plant and mushroom species. Contaminated forage can also lead to high radioactivity levels in animals, including game animals and grazing farm animals put out to pasture, which then is passed on to human through the human diet. The contamination level of animal products is dependent on the radionuclide’s behaviour in absorption rate, metabolic fate (i.e. whether it accumulates in a specific tissue), and the rate of loss.

The monitoring of radioactivity in foodstuffs is naturally highly relevant to estimating doses to the public. During emergency preparedness especially, there might also be a need to control and potentially limit exposure from certain foodstuffs, such as leafy vegetables or the meat of animals on pasture.

There is generally a lot of variability with regard to which food products are sampled, and there is also some variability in other aspects of the monitoring methods. The food products used for monitoring can differ from country to country. Furthermore, the species used in one part of the region might not even exist in another part of the region.

If this sampling medium it to be harmonised, it should probably be limited to two or three food indicator species or types that exist in all countries, for example mushrooms and leafy vegetables. The changes needed for this harmonisation are not too costly or complicated, but it would involve quite a few changes.

4.14. Mixed diet (complete meals/average diet)

Some radionuclides, such as isotopes of cesium, strontium, and iodine, are more environmentally mobile and transfer into the food chain more easily than others. After the Chernobyl accident, radioiodine proved to be the most important radionuclide with regard to human exposure from the food chain in the short term, while in the long term, radiocesium has been the most important nuclide.

The aim of measuring radioactivity in mixed diet is to get representative information on the human uptake of radionuclides via the food chain. Mixed diet samples are usually taken as complete meals, mostly at places where many meals are consumed and the meals represent “normal” everyday meals, such as in hospitals. The mixed diet can also be measured by analysing separate ingredients if information on the representative national diet is available. Rather than expressing the radioactivity of foodstuffs per kilogram, it might be more appropriate to estimate the activity consumed per day per person, as is stated in Euratom recommendation 472/2001.

Data on the radioactivity levels in foodstuffs is highly relevant to estimating doses to the public. During emergency preparedness, there might also be a need to check and potentially limit exposure from foodstuffs. There are some inconsistencies in the sampling methods, but otherwise there are generally many consistencies in monitoring of complete meals or average diet. However, because the mixed diet measurements are based on what foodstuffs are typical in a given country or area, the data would never be directly comparable across borders. However, information about elevated values would still be of international interest in an emergency preparedness situation.

4.15. Indicator biota

Indicator biota can provide information about radionuclide concentrations in biota that is normally not directly consumed by humans. Instead, the contamination levels in indicator biota are important for research in the field of radioecology, by making it possible to track levels, trends, and transfer of radionuclides in many different parts of the environment and in through different food chains. This information can be used as input for radioecological models and can in some cases be used to predict levels in certain food products (for example, increased levels of cesium-137 in lichen and mushrooms can lead to increased levels in reindeer meat).
Because the different countries and regions are home to different species, the potential for harmonising the sampled indicator species would be limited. General findings about the transfer, accumulation and magnification of radionuclides in biota could still be relevant to the international community, but that sort of general information would not necessarily require the harmonisation of data. Most of the countries did not report to be monitoring indicator biota, and the countries that did, also showed variations in methods.

4.16. Sewage

Sewage can be a source of radioactivity to the food chain through the production of fertilisers, and can indicate whether there are elevated levels coming from e.g. storm drains, hospitals, or other contamination sources. The contaminated sewage is eventually, after various degrees of treatment, reintroduced to the environment, often into the sea. This information could therefore still have some international relevance. However, there are very few countries currently monitoring sewage or sewage sludge, so there is not much information available for data exchange for this medium.

5. OUTCOME OF THE TOPICAL DAY: WHAT LEVEL OF AMBITION IS DESIRABLE, AND WHAT IS FEASIBLE?

When the EGNRS held the Topical Day on monitoring of radioactivity in the environment, the main goal was to receive feedback from the experts in the region on the best way to proceed with the work of harmonising the monitoring in the region and exchanging more comparable environmental monitoring data. However, there are different levels of harmonisation to be considered, for example:

- At the lowest level of ambition, the aim could be to harmonise the monitoring data for very few of the sampling media, and to only harmonise the methodology to a minimum extent of compatibility in the countries that already monitor the given medium.

- At a more ambitious level, the aim could be to harmonise all of the media evaluated to be relevant to the international community, and to harmonise the monitoring programme details to the extent of full comparability.

- At the highest, most ambitious level, the aim could be to essentially implement one programme for the whole CBSS region – a multilateral programme in which all countries would monitor the same sampling media, and in which details regarding the sampling methods and analyses would be the same in all of the countries in the region.

The level of ambition would therefore have to be defined, while also taking into account what is feasible. In this respect, which aspects of harmonisation and data exchange are both desirable and possible to achieve should be considered, such as:

- Whether the participating countries should share their environmental monitoring results at all (which would also involve agreement on communication protocols and data formats)

- Whether a common set of radionuclides should be monitored

- Whether common sampling and/or detection methodologies should be used

- Whether sampling and analysis should occur with the same frequency and geographical density

- Whether the same physical quantities and reporting units should be used

These were some of the issues that were attempted to be resolved at the Topical Day on monitoring of radioactivity in the environment. Below, the discussions that took place regarding what level of harmonisation and data sharing would be optimal and the most cost-effective, in addition what it would be feasible to achieve, are reflected.
Which radionuclides are monitored

Which radionuclides are being monitored in the existing programmes is to some extent dependent on what sources are contributing to the existing radioactivity. For example, the countries that monitor the marine environment in the Baltic Sea, which was significantly affected by the Chernobyl accident, are focusing on nuclides associated with the Chernobyl release (mainly cesium-137 and strontium-90). (These efforts are in large part coordinated by HELCOM, whose obligatory analyses consist of radioactive cesium and strontium-90 in water, and cesium-137 and other gamma emitters in sediments and biota.) However, in the North Sea, which also receives significant radioactivity contributions from the reprocessing plant in Sellafield, countries also tend to monitor technetium-99 – the main radionuclide associated with Sellafield releases. This is an example of how it in some cases is logical for different countries to analyse different nuclides.

In other cases, the choices made regarding which nuclides should be measured might not only be based on what radionuclides are the most important in that area, but can also be affected by other factors, such as what has been prioritised historically in the given country, what time series already exist, what equipment has been available, and what analyses are more affordable. The ease of performing an analysis is probably also an important consideration for which radionuclides are reported; for example, if gamma spectrometry is already performed to measure cesium-137, other nuclides in the gamma spectrum may be recorded in the same analysis. These factors might in part explain the current discrepancies among monitored radionuclides in the various national programmes.

However, in many, if not all, of these cases one can still agree upon a common set of radionuclides that are relevant for the whole region, thereby defining a minimum standard for each sampling medium in a normal situation. Additional nuclides that are not relevant to everyone could of course still be monitored in the areas where they are considered important. A list of recommended or optional nuclides could also be developed to help streamline the monitoring programmes. In addition to a minimum standard guideline for normal situations, it could also be helpful to define a list of the most important radionuclides to measure in the event of an emergency, as this could also include hazardous short-lived radionuclides that are not routinely measured. On the other hand, the appearance of a radionuclide would trigger the monitoring of the same nuclide in other states in the region.

Regardless of any minimum standards or recommendations for radionuclides, all countries can still be encouraged to share data for all the nuclides they already measure, even if they are not harmonised, measured and reported by others, or defined as a minimum standard. By sharing data, regardless of harmonisation, in normal situations also makes it possible to quickly share new information in an emergency situation.

Reporting units

In many instances, the easiest aspect to harmonise would be the reporting units. Different sampling media are of course often reported in different units (for example, based on whether it is measured in weight or volume), but sometimes, different countries use different reporting units for the same media.

Some media, including different biota types, can be reported either in dry weight or wet weight. Converting between Bq/kg wet weight and Bq/kg dry weight is more complicated, and harmonisation of these units might therefore involve changes to the procedures; however, these changes would be relatively easy to achieve and involve fairly low costs. Currently, the details on whether units are reported in wet or dry weight are not available for all of the countries in the relevant sampling media, so there is no information verifying whether discrepancies between wet weight and dry weight reporting occurs. However, this is among the details that would need to be defined if the reporting units are to be harmonised.

In other cases, additional information is critical to understanding the measurement results. For example, when it comes to deposition and air monitoring, the duration of the sample collection is also crucial to data interpretation. A standard that includes the sampling duration for the reported unit would therefore also be useful (e.g. Bq/m²/day for deposition data). Metadata that includes the amount of precipitation during the sampling period is also important to the interpretation of radioactivity in deposition samples. When it comes to other media, additional metadata would be desirable in order to be able to properly interpret the results.

Because harmonisation of units is crucial to data exchange and is also a relatively simple and low-cost step, the Topical Day participants agreed that this should be done as one of the first steps in the harmonisation and data sharing process, and the definition of which reporting units are most appropriate should be defined.

Sampling and measurement methods

A much more complicated area for potential harmonisation is all of the various methodologies that are currently used for sampling and analysing the different media. This variability includes the use of different sampling techniques, sample sizes, sample preparation and detection instruments, and details of the sample types.
Differences in methodologies do not necessarily lead to non-comparable data. For some aspects of the methodology, these variations can have minor impact on data compatibility (e.g., sample sizes and instruments used). However, the choices made regarding other aspects of the methodology may have a larger effect on data compatibility. For example, the preparation of seawater samples may or may not involve filtering the water before analysis, and soil sample preparation may or may not include removing any rocks, grass and roots present. Similarly, the depth of soil and sediment samples, or what species are collected for biota samples, also affect the results and lead to data that is not directly comparable.

Harmonising all of the sampling and measurement methods would be both difficult and expensive, and it is probably not crucial in order to share comparable data in the majority of the cases. There was consensus among the Topical Day participants that this goal would be too ambitious at this stage. However, where the methodology does make a difference to the results, as in the cases above (and especially where such changes are relatively easy and inexpensive) it could be very useful to develop a recommendation or a guideline that in clear terms defines a standard approach.

### Sampling frequency and geographical density

Sampling and measurement frequencies and the geographical distribution and density of the sampling sites are also subject to much variation in the existing programmes. Sampling frequencies and densities are partly determined by national priorities and objectives, and are particularly dependent on the financial resources available. Their harmonisation could therefore be inappropriate. In addition, the geographical distribution and density are also affected by local conditions, such as population density, and sampling frequency also has other restricting factors, for example whether the same samples are collected in coordination with other monitoring programmes.

Geographical distribution and density should comply with standards for representative sampling when relevant, but beyond this, it would be difficult and probably unnecessary to attempt to harmonise these aspects of the monitoring programmes. It would still be possible, however, to define a recommended minimum for frequency and/or density for some media (for example, minimum once per year). It could also be relevant to pre-define increased frequencies for sampling/measurement and reporting in emergency situations for the most relevant sampling media. (Perhaps this in some cases might be relevant for geographical distribution and density as well.)

### Format for data sharing

The exchange of comparable and interpretable data is the main purpose of this work, and the data sharing process in itself will also require careful consideration. Today, many radiation safety authorities are reporting monitoring data in different formats to several different organisations, and it is also very time-consuming to use some of these current formats. If the CBSS could agree on a harmonised data formats and communication protocols in the region, this could therefore save everyone reporting data a lot of time.

The participants attending the Topical Day discussed the possibility of using the IAEA IRIX (International Radiation Information eXchange) standard for sharing the monitoring data. IRIX is an xml-based format standard for data exchange that has been developed under the IAEA action plan, in close cooperation with the EC (13). Currently, the IRIX standard is still under development, but the first version is expected in the near future. IRIX can be applied in existing national and international applications, and both the IAEA and the EC are also planning to use IRIX for data exchange after this standard has been finalised. Because the EGNRS considers IRIX to be well-suited for the exchange of environmental radiation data, and because two of the most important international actors on data exchange in the region will also be using this format, the EGNRS participants have expressed willingness to implement IRIX standard after the standard is completed. The ability to include appropriate metadata with the monitoring results would be necessary for certain sampling media.

The participants considered it important to ensure that any reporting should include a proper definition of uncertainty in the reporting, in order to be able to interpret the data appropriately. Monitoring data can also be valuable for scientific purposes, and the group stressed the need to develop and agree on clear rules for the ownership of the data before any data is shared. However, an agreement of data ownership already exists for the exchange of dose rate and air data in the CBSS, and it would be expected that such an agreement would apply to the exchange of other data as well.

### Other potential difficulties and obstacles to avoid

There are of course several problems that can arise in a multilateral project of this scope. This is true both for the overarching issues related to the financial resources available and the political will necessary for such a cooperation, as well as for the practical details relating to issues like sample preparation and data formats. A harmonisation process would also need to take into account any other developments at the international level that are relevant to this topic, seeing as joining efforts and avoiding duplication would be profitable to all parties, both in terms of available expertise and financial resources.
One problem that must be avoided in this process is to create more work than can be handled. It might therefore be a good idea to start with the smallest and most easily manageable tasks as the short-term goals in the initial phase. This would allow the participating countries to decide on standards or recommendations in a manageable scope and work out the practical issues for data exchange with smaller quantities of data, while not being overloaded with work in trying to solve all of the possible issues at once. This approach should also limit the strain on financial resources, while prioritising the quality of the work rather than the quantity.

Harmonisation of monitoring methodologies can also result in issues beyond the necessary work force and resources. Changes that would significantly affect the results may also disrupt existing time series by producing new data that are incompatible with the previous data. Some of these existing time series cover several decades and are important to radioecological research. In many cases, however, there would be ways to estimate compatibility between old and new data.

Another issue of compatibility is due to the fact that the samples themselves sometimes are of different materials. Sometimes, this can be the result of arbitrary choices, while in other cases this can be a logical decision; for example, the indicator plants or food products that are sampled in one country might be of a species that does not even inhabit other countries in the region. If samples of biotic origin are to be harmonised, careful consideration must therefore be placed on finding species or products that are present in across the region or a set of species that are compatible as indicators.

For some sampling media, the monitoring results are highly dependent on external factors that influence the radioactivity levels. These factors can in turn make interpretation of the data difficult. For example, for soil, characteristics like whether the soil is agricultural or undisturbed, the amount/type of nearby vegetation, soil type, dry weight, etc. can be significant to the comparability and interpretation of the results. In the marine sampling media, salinity can similarly affect the radionuclide concentrations. To address this issue, one would need to include this information metadata for the relevant media in the data reporting format. Definitions of what kind of metadata is required would therefore be an important step of data exchange.

**Feasibility and relevance of harmonising different sampling media**

It became clear during the Topical Day that there can be different opinions about which media and nuclides should be prioritised for the project in this initial phase, based on which monitoring objectives are emphasised – for example, whether the monitoring programme has a focus on dose assessments, emergency preparedness or radioecological research.

In the terrestrial environment, soil monitoring can be considered a high priority from the standpoint of radioecology: it provides a good indication of the total amount of radionuclides present in the environment and therefore available for transfer to the food chains. On the other hand, if the assessment of doses to the population is the main purpose for the monitoring, soil monitoring is less relevant, seeing as concentrations in indicator biota and foodstuffs offers a better idea of the amount of radioactivity that is being transferred to our food chain. Regardless of objectives, representative soil sampling is a time-consuming and relatively costly undertaking; however, the sampling frequency can be quite low and still be relevant.

In the marine environment, there might not be as great a need for harmonisation as in other areas, considering that monitoring is to a large extent already harmonised, especially through HELCOM in the Baltic Sea region, but also through OSPAR. The sampling media are fairly well harmonised among these programmes, with the exception of sediments, which is not included in the OSPAR programme. Sediments can be regarded as very important to radioecological understanding and research, but for the purpose of human dose assessments, the monitoring of marine biota, particularly fish, is much more relevant. It should also be taken into account that marine monitoring in open sea is an expensive undertaking, requiring a ship with special equipment, as well as a crew.

Dose rate monitoring and air monitoring is already harmonised and shared for the most part. While these media are very important in estimating concentrations and mapping the spread of radionuclides during the early phase of an emergency situation, deposition measurements are highly relevant in the later phase of emergency management as this is a better indicator for assessing doses to the population and the transfer of radioactivity to the environment. Because deposition also is a sampling medium that is relatively easy and inexpensive to sample, this could also be a candidate for harmonisation and data sharing in the early stages of this project.

Food and drinking water are of course very important for making assessments of radiation doses to the public. Extensive, regular monitoring is probably most relevant in contaminated areas, seeing as these levels can vary, for example due to variations in climatic conditions. Since drinking water and milk are directly comparable across any country, and also cheap to sample, these media are probably the media in this category that are the easiest to harmonise. The mixed diet samples especially, but other food products as well, are also important to dose estimations, but more complicated to compare across borders, due to the different diets in different areas. However, it can still be useful to share the monitoring data even when the samples differ and the monitoring data is not directly comparable. For example, it might be appropriate to learn about radioactivity levels in food products in other countries considering
the import and export of these products in the region.

Best practices and guidelines

While there was general acknowledgement at the Topical Day and the EGNRS meeting that it would be too ambitious to attempt to achieve full harmonisation at this stage, it was agreed that developing best practices for monitoring in the CBSS would be a very helpful next step. This is a step that is also highly consistent with the long-term goals for further harmonisation and data sharing in the region.

Best practices can act as a step towards a form of voluntary harmonisation. It would also be a helpful guide when monitoring programmes are restructured or new ones are implemented, and the hope is that countries in the region would, by consulting these best practices, slowly harmonise their monitoring programmes.

A group of experts would need to be established to examine existing methods and develop the best practices based on what is found to be the best approaches, following international best practices and guidelines when this is available. As a consequence, the development of best practices would not only encourage a process towards a harmonised system for the whole region, but also lead to the enhanced quality of the monitoring programmes in the region. This could be particularly important for countries with limited resources for doing this sort of examination themselves.

The best practices could also be applied in existing multilateral programmes, and for some aspects of the methodology, determining best practices would be particularly helpful. One example is whether or not seawater samples should be filtered. HELCOM’s guidelines do not define these types of sample preparation details; however, it would be achievable to standardise these types of methods, and this would make the samples analysed by individual countries for a multilateral programme more comparable. Given the complexity of the sampling and sample preparation producers alone, the development of a detailed standard would be a helpful tool for both national authorities and international organisations.

The CBSS EGNRS has an advantage for doing this sort of work in that it can be much easier to decide on and implement standards in a smaller and more flexible than in larger organisations. If the work proves successful, the standards could then later be implemented over larger regions, for example in the EC, as it should be easier to find consensus for something that already exists and is working. (The exchange of dose rate measurements was implemented in the same way – it was first shared within the CBSS, and later a similar agreement was adopted in the EU and is now shared through EURDEP.)

Methods for further work

Bearing in mind the need to avoid creating more work than can be properly handled at any given time, as well as the need to avoid putting too much strain on the limited financial resources available, one approach worth considering is to delegate the work to CBSS projects. The projects would be carried out in over a pre-defined limited time period and have a pre-defined scope. This would divide up the process into smaller units of manageable workloads. A group should be established to define these projects. After defining clear project plans, the CBSS could apply for financial support for these projects.
6. CONCLUSIONS

This report has been developed on the basis of discussions in the CBSS EGNRS to improve the environmental radiation monitoring programmes in region by extending the exchange of monitoring data between the countries and by harmonising the monitoring methods in order for the shared data to be comparable. The focus of the work so far has been to get an understanding of the current state of monitoring programmes in the region and to consider the advantages, disadvantages, and feasibility of sharing comparable data for other environmental sampling media as well. The EGNRS Working Group on environmental monitoring has collected information about the existing environmental radiation monitoring programmes in the CBSS and evaluated the results with regard to the programmes’ suitability for harmonisation and data sharing.

The work and preliminary findings of the Working Group were presented at the Topical Day on monitoring of radioactivity in the environment in Oslo 12-13 April 2011 and the subsequent EGNRS meeting 13-14 April 2011. The work and the feasibility of harmonising and sharing data for more sampling media were discussed by the participating experts in these forums. The Working Group’s results and evaluations were welcomed by the EGNRS, and there was agreement in the EGNRS to proceed with this work.

Below are the conclusions that the EGNRS has drawn based on the Working Group’s survey and analysis of the national monitoring programmes and the discussions that took place at the Topical Day.

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The CBSS EGNRS has already established a data exchange system for external gamma dose rate and air monitoring, and it would be appropriate to extend this work.

The CBSS EGNRS members are already obligated to share their external gamma dose rate and air monitoring data through the Agreement on the Exchange of Radiation Monitoring Data. There are some minor variations in the methodologies used when monitoring these media; however, the data produced in the different countries is nevertheless compatible. The EGNRS therefore already has a functioning system in place for data exchange.

The CBSS members and observers are monitoring many of the same radionuclides in many of the same sampling media.

The survey confirms the overall tendency for the CBSS members and observers to monitor many of the same sampling media in their national environmental radiation monitoring programmes. The different countries generally measure one or a few of the same radionuclides in each sampling medium. Practically all sampling media are analysed using gamma spectrometry in practically all of the countries, although when it comes to which gamma nuclides are reported and which other analyses are performed, there is more variation among the programmes.

Other methodological details differ from country to country as well, for example with regard to the details of the sample types collected and the sample preparation procedures. The degree of variability also varies: For a few sampling media, the current monitoring programmes are quite similar in all countries, while for others there are much larger differences.

Current monitoring programmes are already partly harmonised through international organisations, but some incompatibilities exist for these sampling media as well.

The monitoring of external gamma dose rates and air is already harmonised to a large extent and shared through both the CBSS. Monitoring of the marine environment is also partly harmonised among several countries through monitoring agreements within HELCOM and OSPAR. In addition, EU members’ programmes are also partly harmonised through Euratom recommendation 2000/473 on the monitoring of surface water (fresh and marine), drinking water, milk, and mixed diet.

However, several monitoring details still differ for these sampling media as well. This can for example occur in cases when not all of the countries are members of the given organisation, when the methodological details are not specified in the recommendation, or when the countries do not strictly comply with the recommendation.
The sampling media that are most commonly part of national programmes are those that are part of international agreements.

Based on the information the Working Group has been able to collect, the sampling media that are most often included in the national programmes of the thirteen reviewed countries are

- external gamma dose rate, air (14 countries),
- surface freshwater, seawater (12 countries)
- milk, other food products (11 countries),
- deposition, marine sediments, drinking water/ground water (10 countries),
- marine biota (9 countries)

All of these sampling media are also included in the HELCOM and OSPAR guidelines and/or the Euratom recommendations.

There are many objectives for monitoring.

Monitoring is carried out in both scientific, public and preparedness interests. Objectives include, for example, the need to make assessments of doses to the public, make assessments in emergency preparedness situations, inform the public of the radioactivity levels in the environment, maintain competence, and carry out radiological research and develop models. While all countries probably have several objectives for performing their monitoring programmes, it should be acknowledged that the particular focus of a programme may have an effect on which sampling media are prioritised and the other details of the programme, as well as how important harmonisation and data sharing would be considered in that country.

The exchange of compatible data would be beneficial to the international community.

The sharing of additional monitoring data between countries in the region should enable the CBSS countries to better respond to abnormal situations, provide better information to the public, avoid monitoring redundancies and gaps on the regional level, and better predict the movement of radionuclides in the environment. In addition, having good procedures available for sharing of monitoring results would also secure the sharing of the data in an emergency situation. In order for this data exchange to be as useful as possible, the data provided from the different countries should be comparable.

The establishment of a harmonised data exchange system would lead to better and more efficient cooperation in the region and improve the national authorities’ success in achieving the objectives of the existing programmes as well. There was agreement in the EGNRS to move forward with this process.

IRIX could serve well as a format standard for data exchange. The IRIX format standard, which will be used both by the IAEA and the EC after it is finalised, would be a good option for the sharing of monitoring data within the CBSS as well. The format would also need the ability to include appropriate metadata for certain sampling media. By adopting the same standard, everyone can achieve better, internationally harmonised systems while at the same time minimising the integration costs.

Harmonisation and sharing of deposition, drinking water and milk data and harmonisation of reporting units are good candidates to prioritise in the work ahead. Based on the results of the survey and Topical Day discussions, it is clear that harmonisation of the reporting units should be one of the prioritised tasks. There are several sampling media for which the results are reported in different units. Harmonisation of sampling units would be a step towards making the results comparable and more easily interpretable. Furthermore, the harmonisation of these units does not require a lot of resources and can be done in a shorter time frame, and all of the sampling media would benefit from unit standardisation.

Deposition, drinking water and milk are good candidates to prioritise for harmonisation and data exchange in the first stages of this work. Deposition is an important measure in the longer term following a release, in order to determine where the radioactive contamination will settle and be transferred to the terrestrial environment and food chains. It is also relatively easy and cheap to sample and less complex to harmonise than most other media. A similar situation currently exists for milk and drinking water, which are highly
relevant to dose estimations following a release, as well as relatively easy to sample and harmonise. Almost all of the countries reviewed in the survey monitor these sampling media, which makes harmonisation even more relevant to the international community. The harmonisation and sharing of these monitoring data would therefore offer the countries in the CBSS region a more complete picture of radioactivity levels in their vicinity.

The region would benefit from a guideline defining a minimum set of radionuclides to be monitored in each sampling medium. Overall, many nuclides are measured in addition to the gamma spectrum, but the choices made regarding which additional nuclides to measure in each sampling medium can vary greatly from one country to the next. This is especially true in the cases where the sampling medium is not included in any of the existing multilateral programmes. The region could therefore benefit from a guideline for a minimum set of radionuclides to monitor in each sampling medium. A guideline for additional optional radionuclides that it would be relevant to monitor could also be beneficial.

The CBSS would benefit from the establishment of best practices. The full harmonisation of the monitoring programmes in the region would be a very difficult task, but a set of best practices for monitoring radioactivity in the environment could be a very helpful tool. The development of best practices would serve as a step towards voluntary harmonisation in the region, while at the same time enhancing the quality of national and multilateral monitoring programmes as they are implemented.

A good approach for further work is via specific projects. Considering the need to avoid creating too much work at once, defining specific projects that would contribute to harmonisation and data exchange in the region would be a good approach. Projects are limited in time and scope, and can also be eligible for external funding. Projects could therefore both be a helpful tool for dividing the work up into manageable, limited tasks, while also avoiding putting too much strain on the financial resources in the CBSS countries.

7. OUTLINE OF FURTHER WORK

The EGNRS has previously decided, in line with the recommendations of the Committee of Senior Officials (CSO), to use a more project-oriented working method. This will also apply to the work on environmental monitoring.

Based on the information that has been gathered for the existing environmental radiation monitoring programmes in the CBSS region, the discussions that took place at the Topical Day and the subsequent EGNRS meeting, the EGNRS decided to continue the process to further harmonise and share environmental radiation monitoring data in the CBSS. The EGNRS has provided recommendations for how to proceed with this effort.

The EGNRS recognised that care must be taken to avoid creating too much work at once in the process. In this initial stage, the decision of which tasks should be prioritised in the harmonisation and data sharing process should be based not only on what information is important and internationally relevant, but also on what tasks would be the least complex and most feasible in terms of available resources.

The EGNRS decided to:

Establish a Working Group to generate coordinated project proposals

The EGNRS should establish a Working Group to coordinate the development of project proposals and specific project work plans that would facilitate further harmonisation and data exchange in the initial stages of the process.

The EGNRS recommends that this Working Group should develop a set of coordinated project proposals in line with the recommendations below.

a) Identification and development of best practices for monitoring radioactivity in the environment

The Working Group should develop and propose a project that would result in the establishment of a set of best practices for monitoring of radioactivity in the environment. The development of best practices should involve experts that are qualified to support the relevant educated decisions.

b) Harmonisation of physical quantities and units

The Working Group should develop and propose a project that would result in the harmonisation or standardisation of physical quantities and reporting units in the CBSS. Possible approaches are to arrange for an agreement among the CBSS member states or to develop recommendations or guidelines.
c) Generation of comparable data and harmonised parameters for the prioritised sampling media

The Working Group should develop and propose a project that would direct the countries to generate comparable data for each sampling media that is considered a priority. In addition to producing monitoring results that are comparable across borders, sets of common parameters should be defined and reported when data is exchanged. The evaluations of this report, which consider the sampling media’s importance as well as the relative ease of harmonisation, suggest that deposition, milk and drinking water are good candidates for priority. Which harmonisation steps would be necessary for the data to be comparable, would also need to be defined.

d) Establishment of a joint format for data exchange

The Working Group should develop and propose a project that would results in the identification of a suitable format standard for data exchange. It should be based on international standards, if possible. The IAEA IRIX format standard should be considered as a first candidate for the sharing of monitoring results.

e) Development of guidelines defining which key radionuclides should be monitored as a minimum standard in each sampling medium

The Working Group should develop and propose a project that would result in the development of guidelines defining which key radionuclides should be measured as a minimum standard for each sampling media. Additional radionuclides of relevance should also be identified. It should also be considered whether the project should identify radionuclides of interest during different types of emergency situations.
REFERENCES


