Inventory of Member States' Environmental Radioactivity Monitoring Systems

Final report

Service contract ENER/2019/NUCL/SI2.797734

Written by IRE
December – 2021

EUROPEAN COMMISSION

Directorate-General for Energy
Directorate D — Nuclear Energy, Safety and ITER
Unit D.3 — Radiation Protection and Nuclear Safety

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Concluding Report

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15 December 2021

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Glossary of abbreviations

EC: European Commission

EU MS: European Union Member States

GDRP: General Data Protection Regulation

IAEA: International Atomic Energy Agency

JRC: The Joint Research Centre

NORM: Natural Occurring Radioactive Materials

NPP: Nuclear Power Plant

RW: Radioactive Waste

WHO: World Health Organization

WS: Workshop

1. Introduction

1.1. Project background

Radioactivity, whether it is the result of human activities or of natural origin, is not without risk for humans and the environment. That is why practices involving radioactive substances are strictly regulated and controlled. Particularly discharges of radioactivity into the environment have to comply with strict standards. However, enforcing strict regulations does not guarantee that the population will not be exposed to (often) small levels of radioactivity released to the environment through authorized practices. Additionally, incidents and accidents, which can never be ruled out, may result in the dispersal of very significant amounts of radioactive substances into the environment, exposing the population to radiation doses significantly higher than the level of natural radiation. For this reason, the level of radioactivity in the environment has to be systematically monitored to detect any abnormal situation and to take appropriate action whenever needed. Environmental monitoring is hence defined as the measurement of external dose rates due to sources in the environment and/or of radionuclide concentrations in environmental media.

The Treaty establishing the European Atomic Energy Community (EURATOM), signed in 1957, promotes the development of peaceful uses of nuclear energy in a safe and sustainable manner. The EURATOM Treaty, now applicable to all of 28 Member States (MS) of the European Union (EU), represents therefore the main legal basis for regulating the civil uses of nuclear energy and ionizing radiation in general.

Chapter 3, *Health and Safety*, of Title II of the EURATOM Treaty deals on the one hand with the establishment of Basic Safety Standards for the protection of the health of workers and members of the public (Articles 30 – 33) and on the other hand specifically with the surveillance of levels of radioactivity in the environment (air, water, soil) as established in Articles 35 – 38.

Article 35 stipulates that each Member State shall establish the necessary infrastructure to carry out continuous monitoring of the level of radioactivity in the air, water and soil and to ensure compliance with the basic standards. The European Commission, hereinafter referred to as the "Commission", shall have the right to access these facilities and verify their operation and efficiency. Article 36 states that the authorities shall periodically report to the Commission about the monitoring referred to in Article 35, so that the Commission is kept informed on the levels of radioactivity to which the public is exposed. Furthermore, Commission Recommendation 2000/473/EURATOM of 8th June 2000 on the application of Article 36 of the EURATOM Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole, explains it is important that, in addition to air, water and soil, levels of radioactivity be also determined in foodstuffs. Hence, Commission verifications under Article 35 shall also cover the monitoring of foodstuff, either as mixed diet or as raw materials (eatable vegetation, milk, meat, drinking water, etc.).

In this context, the project entitled "Inventory of Member States Environmental Radioactivity Monitoring Systems" was initiated by the European Commission which aimed at developing a comprehensive overview and inventory of environmental monitoring systems in place in the European Union Member States.

1.2. Project objectives and scope

1.2.1. Project objectives

The main objective of the project was twofold:

i) To assist the Commission for its future verifications in the frame of the Article 35 of the Euratom Treaty by providing up-to-date information on the current state of environmental and food radioactivity monitoring across EU covering both legal/regulatory aspects and technical capabilities;

ii) To give the opportunity to the Member States to assess their national situation pertaining to their monitoring system for environmental and food radioactivity in comparison with the situation prevailing in other MS.

Within this principal objective, the project encompassed an additional specific objective which was to assess the pertinence of the Commission Recommendation 2000/473/Euratom. This evaluation was based on the conclusions of the present study and in the light of the technological current developments.

1.2.2. Project scope and duration

The project focused on the scope of the Commission verifications related to the radioactivity monitoring in the environment and food, e.g.:

- National and regional stakeholders;
- National legislative, regulatory and administrative framework;
- National and regional monitoring programs both in routine and emergency situations (automatic and/or laboratory-based monitoring);
- Geographical areas covered, not only nuclear fuel cycle installations, radioactive isotope production plants, hospitals, and NORM but also in densely populated area;
- Technical inventory of automatic monitoring systems: design, set-up, features, controlled media, measured parameters, availability, data communication, data analysis and management, etc.;
- Technical inventory of laboratory-based monitoring networks: methods used for sampling, samples preparation and analysis, management of data and samples, Laboratory Information Management System (LIMS), accreditation (procedures, validation of methods, follow-up and control of equipment, traceability of measurement, proficiency tests, training, etc.);
- Communication to public of the results of the national territory radiological surveillance;
- Bilateral agreements;
- Information to the public;
- Specific monitoring programs.

The scope of the project covers the 27 EU MS[1] although representatives of Candidates Countries (Albania, The Republic of North Macedonia, Montenegro, Serbia and Turkey) as well as representatives from Norway, Belorussia and Ukraine and of international organisations (IAEA, WHO) are additional stakeholders considered within the project development.

Initially the project implementation was due over a period of 2 years (February 2019 to February 2021), nevertheless due to the sanitary situation caused by the Covid-19 pandemic, the project duration was extended until end of 2021.

The project was developed by a Consortium built on four experienced companies: IRE (project leader, Belgium), SCK•CEN (Belgium), AGES (Austria), ENCO (Austria).

1.3. Purpose of the concluding report

The present report aims at gathering in one document the main findings of the analysis performed on the monitoring systems in place in the 27 EU MS and the conclusions drawn from the study. Its main objective is to present an overview

[1] As the United Kingdom left the EU (BREXIT), the Country was declared out of the project scope and thus the study focused only on 27 EU MS.

of the radiological monitoring situation in the 27 EU MS based on the information collected in the frame of the project. The report details also the situation concerning the compliance with the recommendations 2000/473/Euratom in the 27 EU MS. The methodology applied for performing the analysis is described in section 2 of the report.

2. Project development and methodology

2.1. Project development

The project was implemented following a stepwise approach under three main phases as depicted in Figure 1.

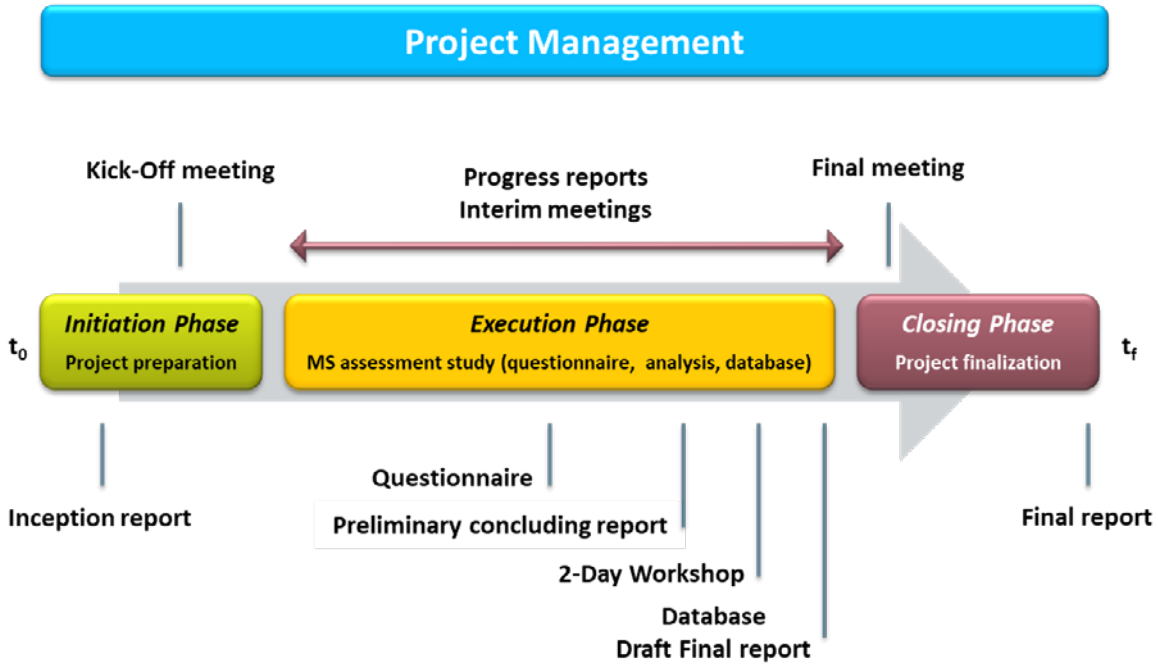

Figure 1: stepwise approach used for implementing the project.

The initiation phase mainly included the kick-off meeting of the project, the development of a well-defined working plan for its implementation, including planning of the tasks and distribution of the activities performed among the consortium members. This phase was also used for identifying all relevant stakeholders, collecting all technical verification reports, main conclusions and recommendations of the EC under Art. 35 as well as other publicly available information in relation with the monitoring of the radioactivity in the environment.

The execution phase consisted of the implementation of the technical tasks of the project. More details on the tasks are provided in the section 2.2 of this report.

The closing phase involved the organization of the project final meeting during which the final report of the project was presented as well as the project evaluation.

2.2. Project tasks

The project comprised the development of four technical tasks as shown in Figure 2.

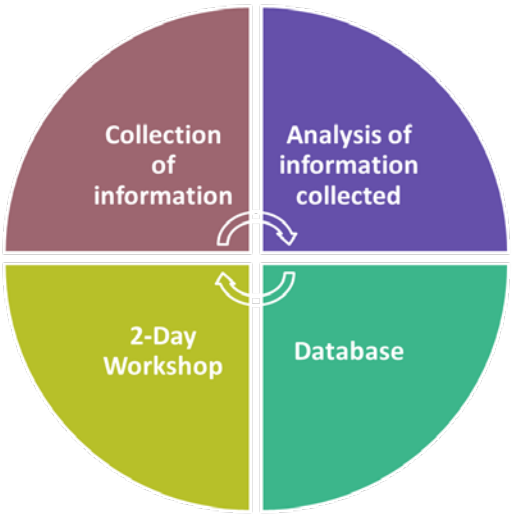

Figure 2: representation of the four technical tasks of the project.

2.2.1. Task 1 – collection of information

The first technical task of the project was devoted to the collection of information on the national infrastructure and practical arrangements for environmental radioactivity monitoring in the EU MS and other related data. To do so, a stepwise approach was used as described in Figure 3.

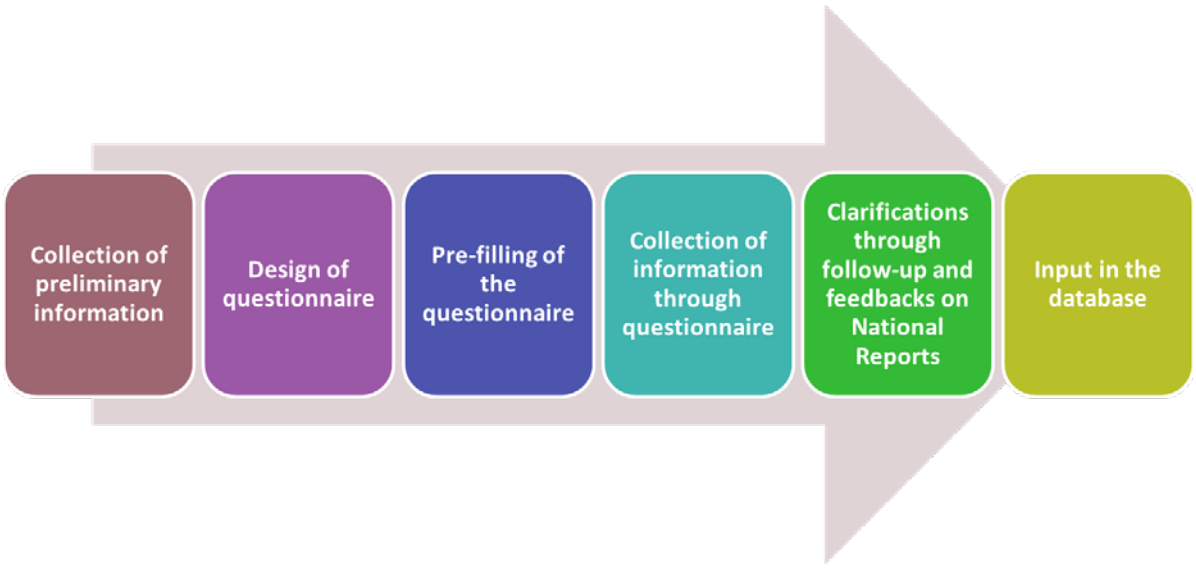

Figure 3: stepwise approach used for the collection of information.

A customized questionnaire was built, and its structure and content approved by the EC. The questionnaire was then pre-filled by the consortium members using information acquired from public sources such as Art. 35 technical verification reports. The partially completed questionnaires were sent to the Art. 35 contact point of each EU MS to verify the accuracy of the pre-filled information, to correct it if necessary, and to provide all other missing information. The strategy of sending pre-filled questionnaires to EU MS was used for minimizing EU MS efforts in sharing the requested information.

Further requests of information or clarification also took place through email exchanges between the consortium members and the 27 EU MS contact points as well as using videoconferences when needed. Finally, the collected information was entered into the database developed within the task 3 of the project.

2.2.2. Task 2 – Analysis of the information collected

The second technical task of the project focused on the analysis of the information collected during the task 1. The evaluation was divided between the consortium members for speeding up the process. The analysis was structured around eight topics as shown in Figure 4.

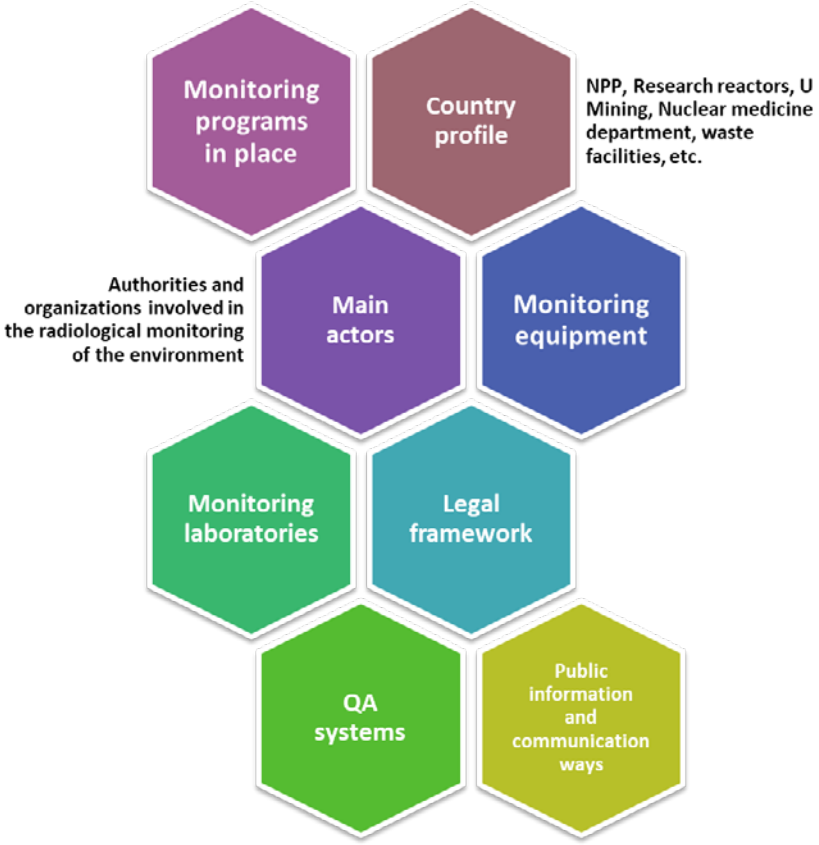

Figure 4: Representation of the eight topics used for analyzing the information collected on EU MS monitoring systems.

Based on the information collected using the questionnaire, the information was analyzed by:

- Comparing the different EU MS in the light of the 8 topics;
- Analyzing the compliance of each country with the IAEA RS-G-1.8 general guidelines;
- Analyzing the compliance of each EU MS with the Commission recommendations 2000/473/Euratom;
- Identifying good practices and needs for improvements.

The analysis performed was then reported in the form of national reports and of this concluding report with the objectives of identifying good practices and needs for development for each country and to provide the EC with a cartography of the monitoring systems in place in the EU MS.

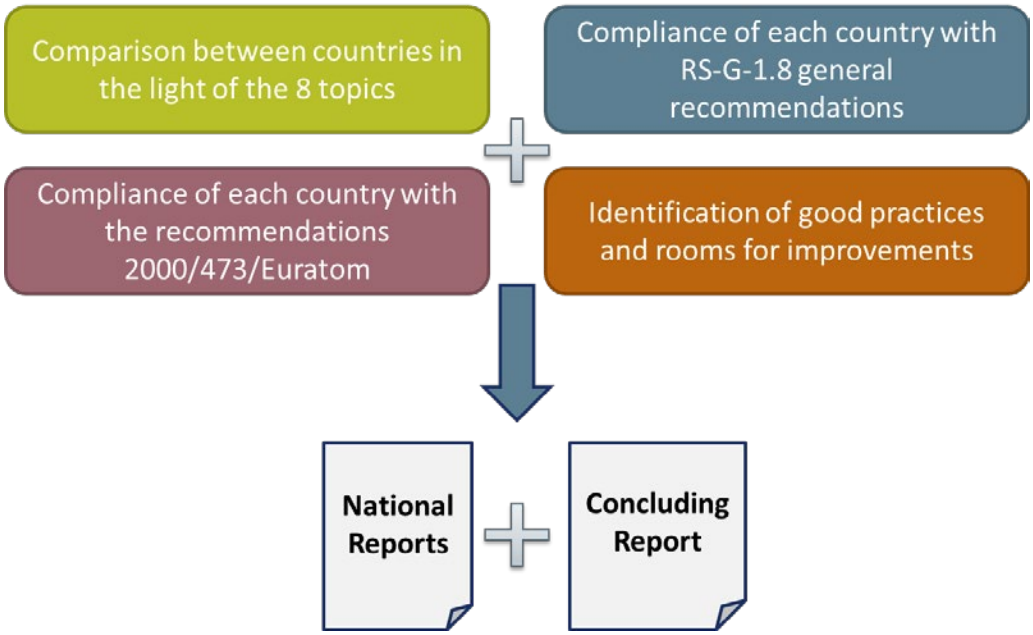

Figure 5: general structure of the analysis performed.

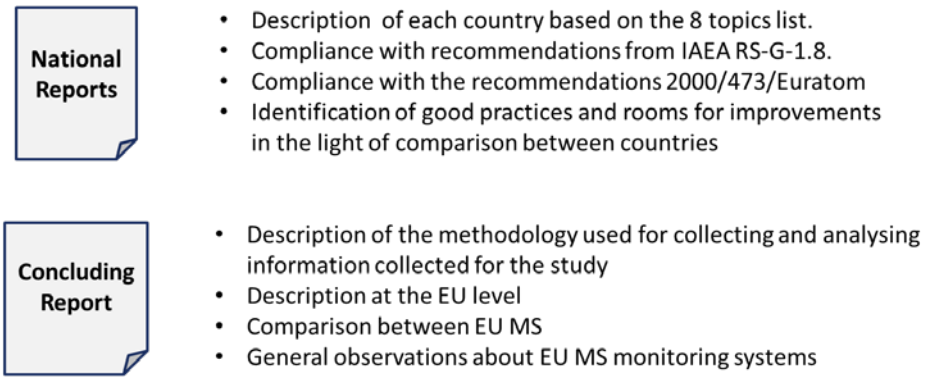

Figure 6: Main contents of the national reports and of the concluding reports.

Regarding the national reports, the following endorsement/review process was followed:

- Step 1: Draft of the national report template submitted to the EC for approving its structure;
- Step 2: Draft of national reports based on the information collected thanks to the questionnaire;
- Step 3: Draft of the national reports sent to EU MS for review and including requests for further clarification;
- Step 4: Update of the national report drafts based on the comments received from the EU MS;
- Step 5: Send version of the national reports endorsed by the EU MS to the EC for comments;
- Step 6: Revision of the reports according to the EC comments;
- Step 7: Send reports to EU MS with a set of questions for preparing the 2-day workshop organized within the task 4 of the project;
- Step 8: Final update the national reports if relevant comments received from EU MS.

Regarding the concluding report, the following reviewing process was followed:

- Step 1: Draft of the concluding report based on the information collected and on the national reports;
- Step 2: Send the draft of the concluding report for comments to the EC;

- Step 3: Revision of the draft of the concluding report in the light of the EC comments;
- Step 4: Present the concluding report during the 2-day workshop organized within task 4;
- Step 5: Update the concluding report if needed in the light of information exchanges during the workshop.

2.2.3. Task 3 – Database

The third technical task of the project consisted of the development and the commissioning of a database for hosting all the information collected on EU MS national arrangements for environmental radioactivity monitoring.

The database was developed by ENCO and according to the EC requirements (web-based database, accessible via internet using different browsers, based on permissions granted to authorized users, etc.). Its design is also similar to the structure of the questionnaire that was used for collecting information during the task 1.

The database allows among others to enter, store, update, search and retrieve the information submitted by each EU MS under the task 1.

The database was developed as soon as the questionnaire structure was approved by the EC. It was tested all along the project duration by several members of the consortium while populating it with the information collected. This process has allowed to fix some issues encountered at early stages of the database development and to ensure that it will remain friendly to use.

The database was also presented on different occasions during meetings between the EC and the consortium to show how to use it and update it. It was also introduced to the EU MS during the Art. 35 meeting on October 14th 2020.

A detailed report on the design of the database, how to use it and including the minimum requirements needed for its use was also handed over to the EC to ensure its proper future maintenance if needed.

The consortium also supported the EC and JRC for transferring the database on their servers.

Figure 7: Print screen of the DB home page.

2.2.4. Task 4 – 2-day workshop

The final technical tasks of the project consisted of the organization of a 2-day workshop in Brussels. Representatives from the 27 EU MS, the EC, the consortium members in charge of the project development, the JRC, candidates' countries were invited to participate in the workshop. It aimed at:

- Presenting the findings and results of the study (the preliminary version of this concluding report);
- Getting feedback from the participants on the Commission recommendations 2000/473 Euratom;
- Discussing potential development needs for the period 2021-2030;
- Sharing between EU MS their experiences in relation with the development and implementation of a radiological monitoring program in their respective Countries;
- Demonstrating the Database developed during the project.

3. Cartography of the radiological and monitoring situations in the 27 EU MS

3.1. Introduction on analysis performed

Prior presenting the analysis conducted in the frame of the project, it is important to agree that the study and analysis performed represent a picture of the EU MS monitoring systems at a given time. They are based on information provided and collected from EU MS representatives through their replies to the questionnaire and from clarifications obtained as part of the national reports reviewing process.

3.2. Sources of radioactivity in the 27 EU MS.

15/27 of EU MS have nuclear power plants on their territory (Figure 8). It corresponds to 175 NPP reactors from which 69 are under shutdown or decommissioning conditions and 106 are in operation as listed in table 1. More than half of the total NPP reactors in operation in the EU MS are located in France (56 out of 106). There are also four nuclear reactors under construction (one in Finland, one in France and two in the Republic of Slovakia).

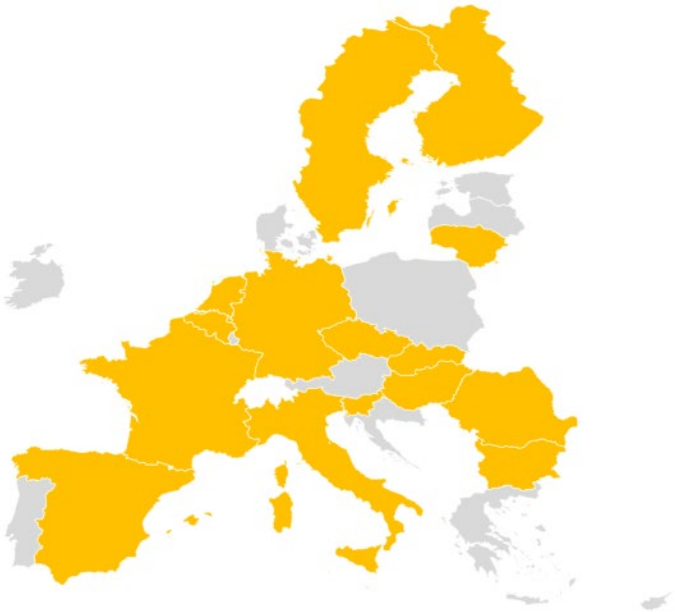

Figure 8: EU MS with NPP on their territories (in orange).

Table 1: List of EU MS having NPP reactors on their territory in 2021.

EU MS	Number of NPP reactors on MS territories	NPP reactors in operation on MS territories
Austria	0	0
Belgium	8	7
Bulgaria	6	2
Croatia	0	0
Cyprus	0	0
Czech Republic	6	6
Denmark	0	0
Estonia	0	0
Finland	4	4
France	70	56
Germany	36	6
Greece	0	0
Hungary	4	4
Ireland	0	0
Italy	4	0
Latvia	0	0
Lithuania	2	0
Luxembourg	0	0
Malta	0	0
Netherlands	2	1
Poland	0	0
Portugal	0	0
Romania	2	2
Slovakia	7	4
Slovenia	1	1
Spain	10	7
Sweden	13	6

Most of EU MS with NPPs have also other nuclear reactors (research reactors) on their territories. The only four countries with NPPs but without other nuclear reactors are Spain, The Slovak Republic, Lithuania and Bulgaria. Countries having other nuclear reactors (but no NPP) on their territories are Portugal, Greece, Austria, Poland and Latvia (Figure 9).

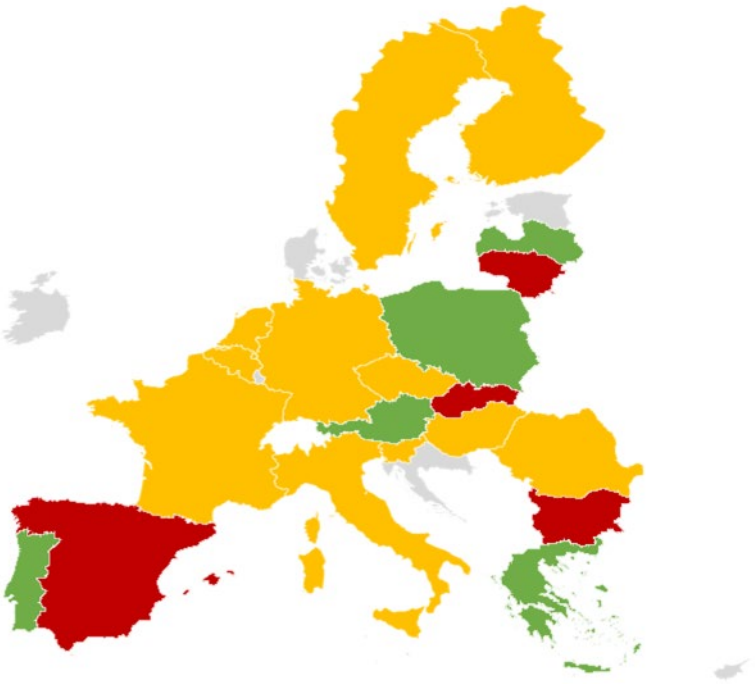

Figure 9: in orange: EU MS with NPP and other nuclear reactors, in red: EU MS with NPP but without other nuclear reactors, in green: EU MS without NPP but with other nuclear reactors on their territories.

The main common types of facilities using radioactive open sources across the 27 EU MS territories are nuclear medicine departments, research laboratories, cyclotrons (and other particle accelerators) and radiotherapy departments as depicted in figure 10.

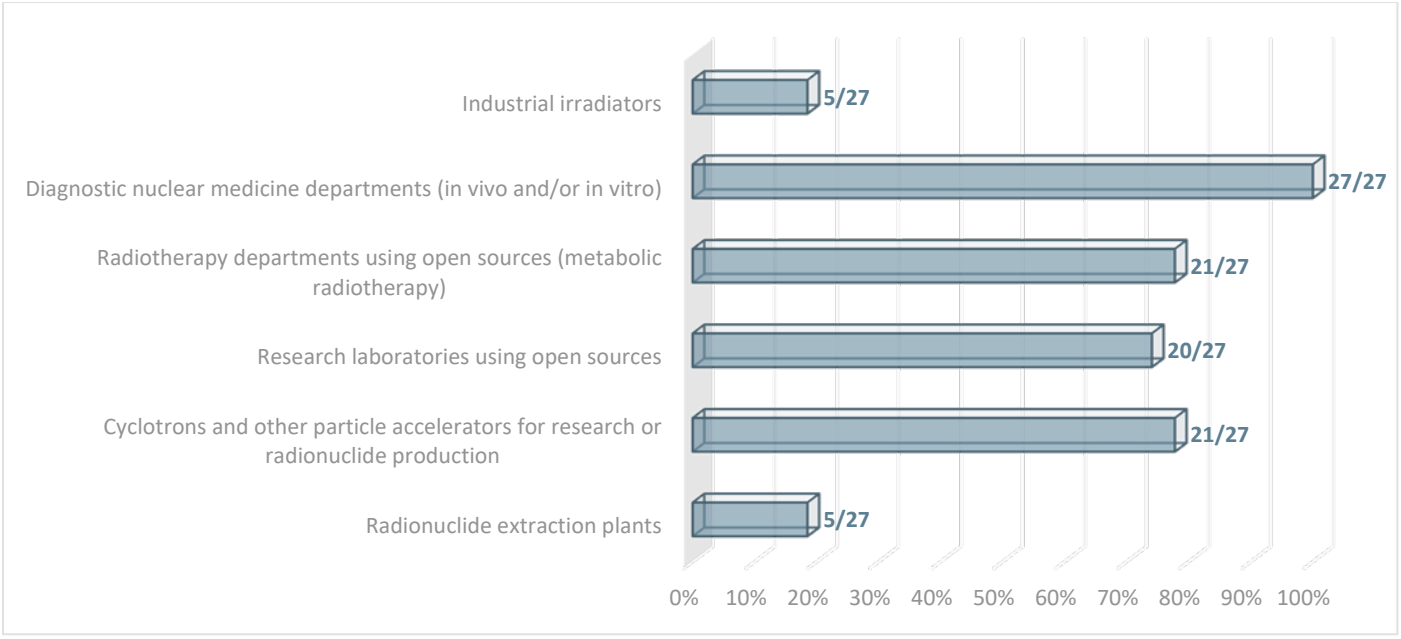

Figure 10: EU MS mentioning the same types of facilities using radioactive open sources across their territories.

The figure 11 presents the most common types of nuclear fuel cycle facilities existing in the EU MS (corresponding mainly to MS with NPP). From the 15 EU MS having NPPs on their territories, only Slovenia does not have a spent fuel storage facility. Poland is the additional country mentioning a spent fuel storage facility. EU MS indicating U/Th mining and milling facilities on their territories are Estonia, The Netherlands, Poland, Portugal, Romania, Spain and Sweden.

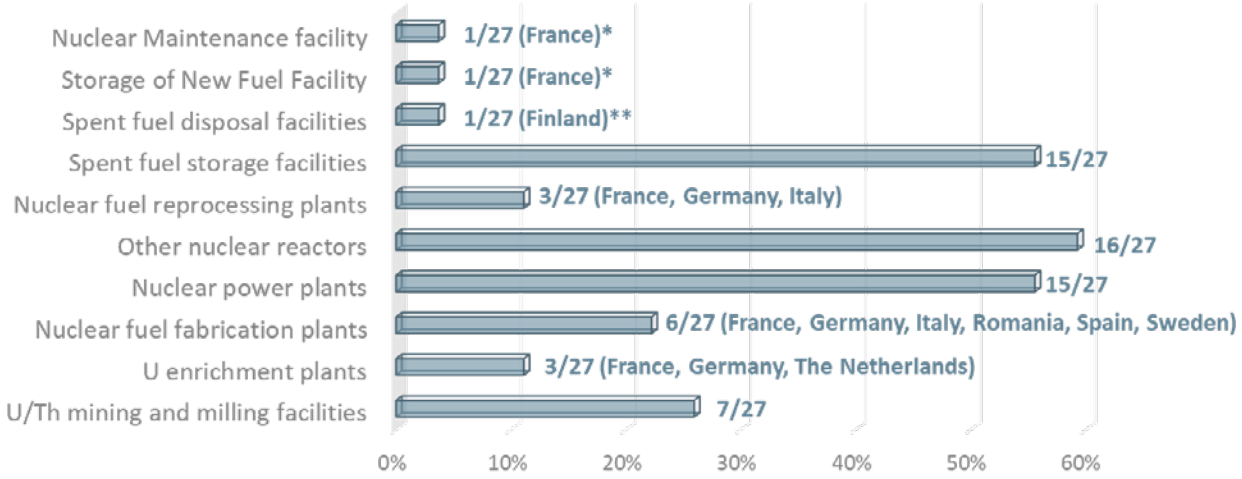

Figure 11: EU MS having the same types of nuclear fuel cycle facilities on their territories.

*Storage of new fuel facilities: Bugey inter-regional warehouse (MIR) and Tricastin unranium-bearing material storage yard
*Nuclear maintenance facility: Tricastin operational hot unit (BCOT)
** under construction in Onkala

Regarding the types of waste management facilities in the EU MS (figure 12):

- 15/27 of EU MS report having RW treatment plants on their territory;
- 22/27 of EU MS have RW storage facilities. The EU MS not reporting RW waste storage facilities are The Czech Republic, Hungary, Ireland, Luxembourg and Malta. In that case, RW are stored at the operator's facilities;
- 14/27 of EU MS mentioned having RW disposal facilities in their country.

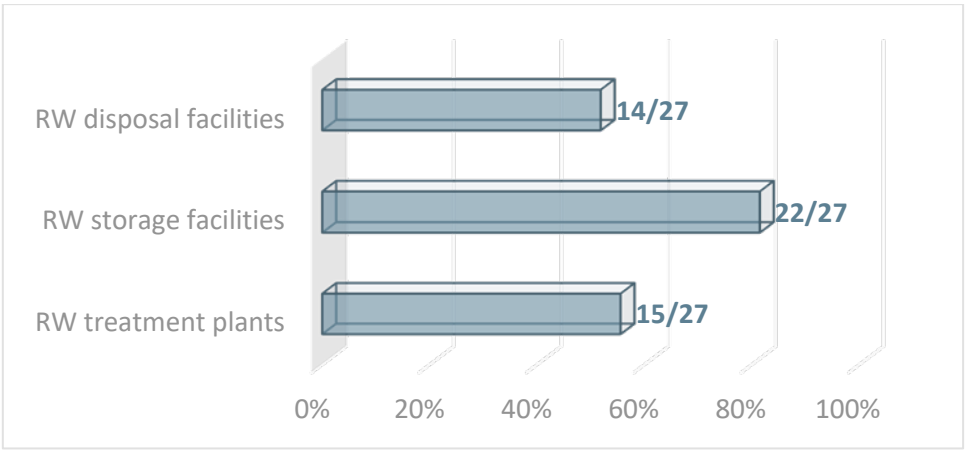

Figure 12: EU MS having the same types of waste management facilities on their territories.

Several EU MS have reported areas of elevated environmental radioactivity on their territory (see figures 13a-c):

- 16/27 of EU MS have identified areas contaminated with natural radionuclides as a result of NORM industries;

- 16/27 of EU MS have identified radon prone areas on their territory;
- 7/27 of EU MS have reported the identification of areas contaminated with artificial radionuclides as a result of radiation emergencies or past practices.

(a) (b) (c)

Figure 13: EU MS with identified (a) radon prone areas, (b) areas contaminated with artificial radionuclides as a result of radiation emergencies or past practices and (c) areas with natural radionuclides as a result of NORM industries.

The figure 14 presents the main industries present in the EU MS and giving raise to NORM discharges.

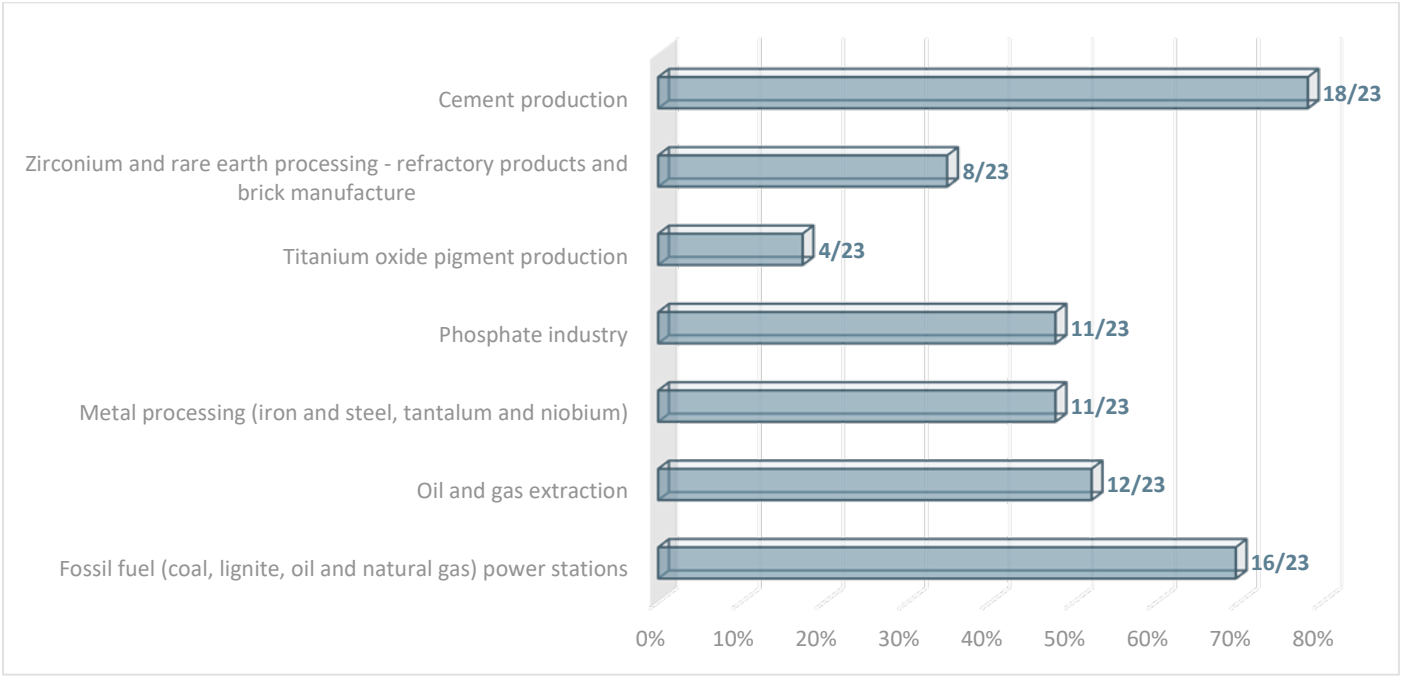

Figure 14: EU MS with similar industries giving raise to NORM discharges in their country. No information reported for Slovenia, Malta, Italy and France

3.3. Overview of the monitoring programs implemented in the 27 EU MS

3.3.1. General information

In normal situations, all EU MS implement national programs for the radiological monitoring of the environment, drinking water and foodstuffs (figure 15). In case of emergency situations, these monitoring programs are not always covered under specific frameworks in all EU MS. It does not mean that in case of an incident no response will take place, it means that in the following countries there are no pre-defined emergency monitoring programs under specific regulations:

- Estonia and Malta do not report having emergency monitoring programs of the environment;
- Croatia, Estonia, Luxembourg, Malta and Portugal do not report having emergency monitoring programs of foodstuffs;
- Croatia, Estonia, Luxembourg, Malta, and Portugal do not report having emergency monitoring programs of drinking water.

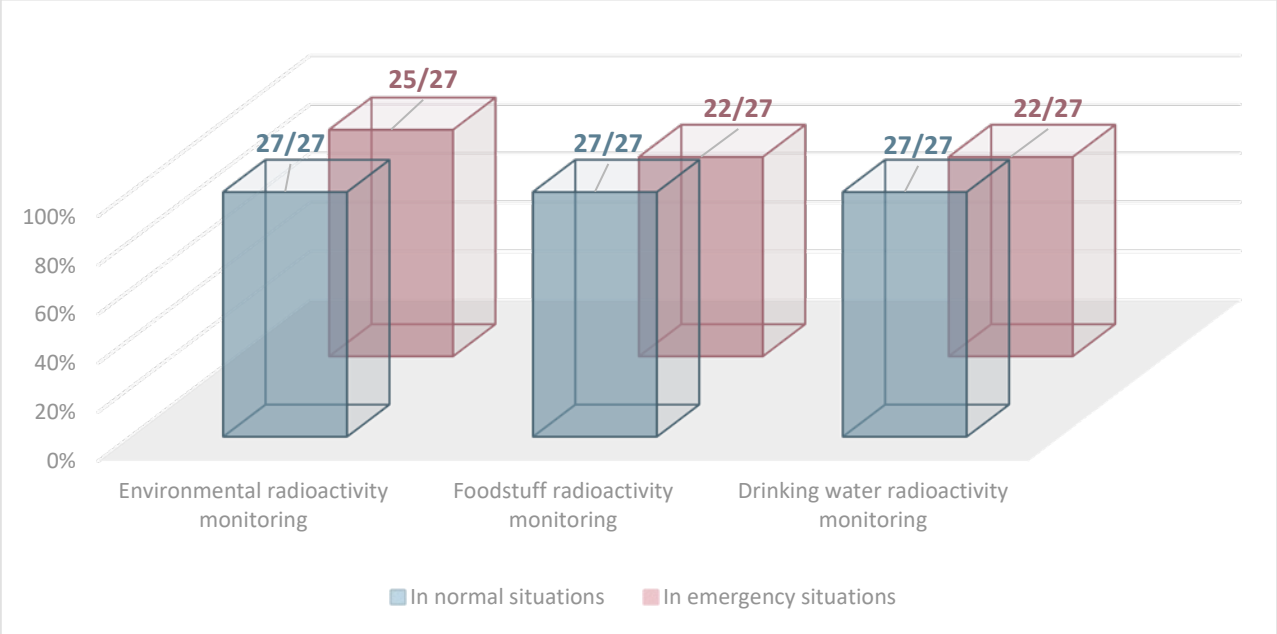

Figure 15: Types of monitoring programs developed in the 27 EU MS in normal and emergency situations.

There are different types of authorities and bodies involved and responsible for the monitoring programs in the EU MS. As shown in figure 16, there is no harmonization between the EU MS in the types of authorities involved in the different monitoring programs implemented, but the following trends can be observed:

- Main authorities involved in the monitoring of the environment are nuclear regulatory bodies, radiation protection authorities, environment protection authorities and emergency response organizations;
- Main authorities participating in foodstuffs monitoring programs are food safety, agriculture, public health, sanitary-veterinary, import/export and radiation protection authorities and the nuclear regulatory bodies;
- Public health and radiation protection authorities as well as the nuclear regulatory bodies are the main organizations involved in the monitoring of drinking water. Water distributing companies participate in the monitoring program of water intended to the human consumption in more than half (15/27) of the EU MS.

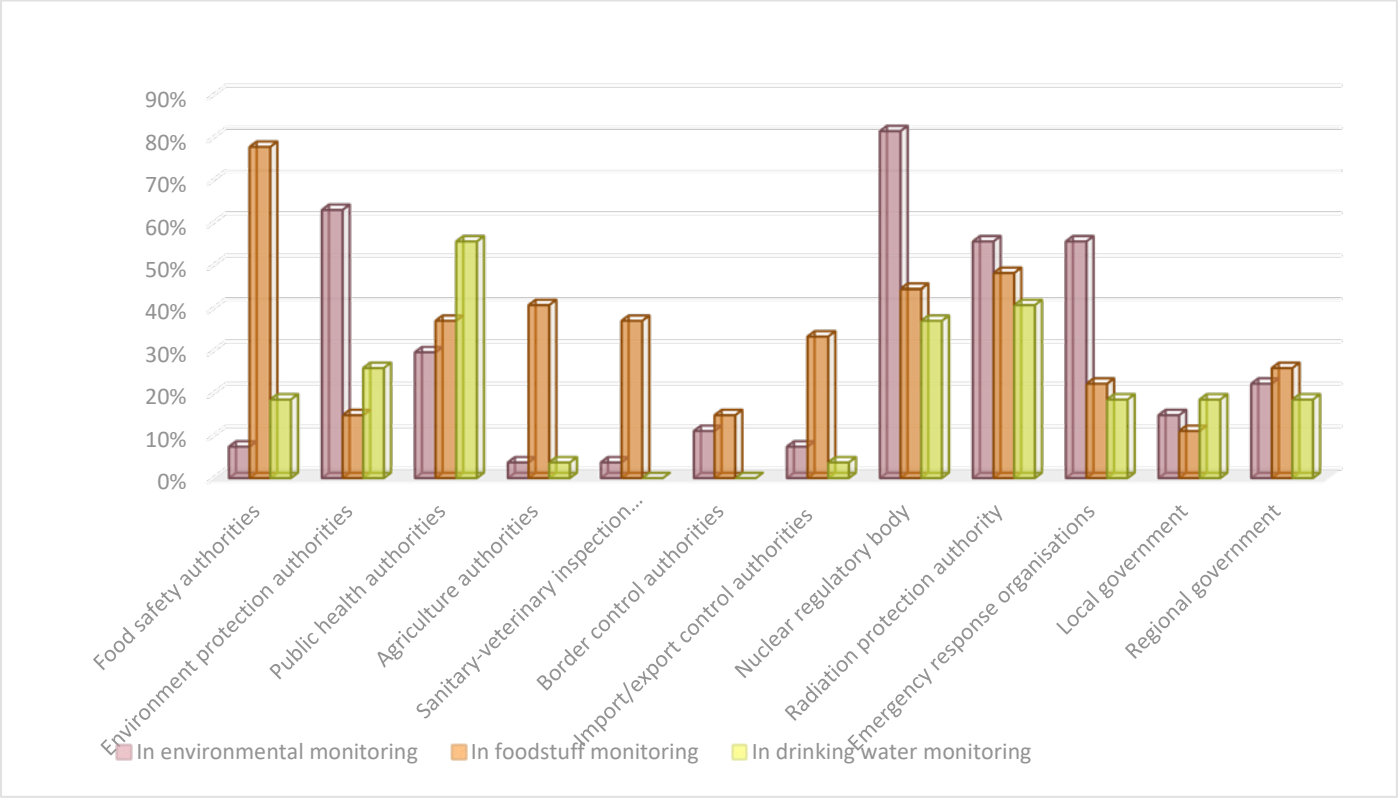

Figure 16: Main types of authorities involved in EU MS monitoring programs.

The 27 EU MS have developed regulatory frameworks governing the monitoring of the environment, foodstuffs and drinking water. The EU MS legal and regulatory frameworks are generally based on:

- The Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation;
- The Council Directive 2013/51/Euratom laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption.
- The IAEA GSR Part 3 – Radiation protection and safety of radiation sources: International Basic Safety Standards;
- The IAEA Safety Guide RS-G-1.8 – Environmental and source monitoring for purposes of radiation protection;
- The IAEA GSR Part 7 – Preparedness and Response for a Nuclear or Radiological Emergency;

Surprisingly, based on the information collected, there is no mention of the Commission Recommendation 2000/473/Euratom as document of reference for the development of the EU MS monitoring programs.

3.3.2. On-line and off-line monitoring in EU MS

Environmental media and foodstuffs are routinely monitored in EU MS via on-line and off-line monitoring programs.

Air media (figure 17) is monitored in all EU MS via on-line continuous monitoring of ambient gamma dose rates using measuring stations (commonly equipped with GM detectors and/or NaI detectors for radionuclides identification) spread across EU MS territories and in the surrounding of NPPs. Aerosols are monitored in all EU MS through off-line monitoring via continuous collection and periodic measurements of samples (filters) using air-pumping stations. 18/27 EU MS have

also reported having automatic air-pumping systems equipped with either NaI or HPGe detectors allowing the determination of radionuclides in air (aerosols and gaseous) continuously and on-line. Radon in air is monitored on-line in Spain, Slovenia, Luxembourg and Germany. It is also monitored off-line in Luxembourg and Lithuania via sampling specific campaigns and in Cyprus, Czech Republic and Estonia as service on-demand. Air media is also monitored off-line via collection of precipitation and dry atmospheric deposition in 22/27 and 15/27 of EU MS respectively.

Figure 17: Air monitoring in EU MS

Water media is principally monitored in EU MS via the collection of periodic samples measured later on in laboratories as shown in figure 18. It can be pointed out that 7/27 of EU MS (Portugal, Netherlands, Luxembourg, Latvia, France, Germany, Belgium) also monitor surface water using continuous on-line monitoring. Seawater monitoring is organized in 18 out of 21 EU MS bordered with sea (no seawater monitoring is carried out in Bulgaria, Finland and Portugal). There are routine monitoring programs of drinking water in place in all EU MS except in Denmark.[2] Monitoring of drinking water using off-line continuous collection and periodic measurements of samples are performed in Austria and in Greece.

[2] In Denmark, groundwater is monitored every third year. Based on this, as well as several nationwide measurements of radioactive substances in Danish drinking water, the Danish Health Authority assessment is that the activity content does not exceed the EU directive parameter value for indicative dose. Thus, there is no additional monitoring program for radioactivity in Danish water.

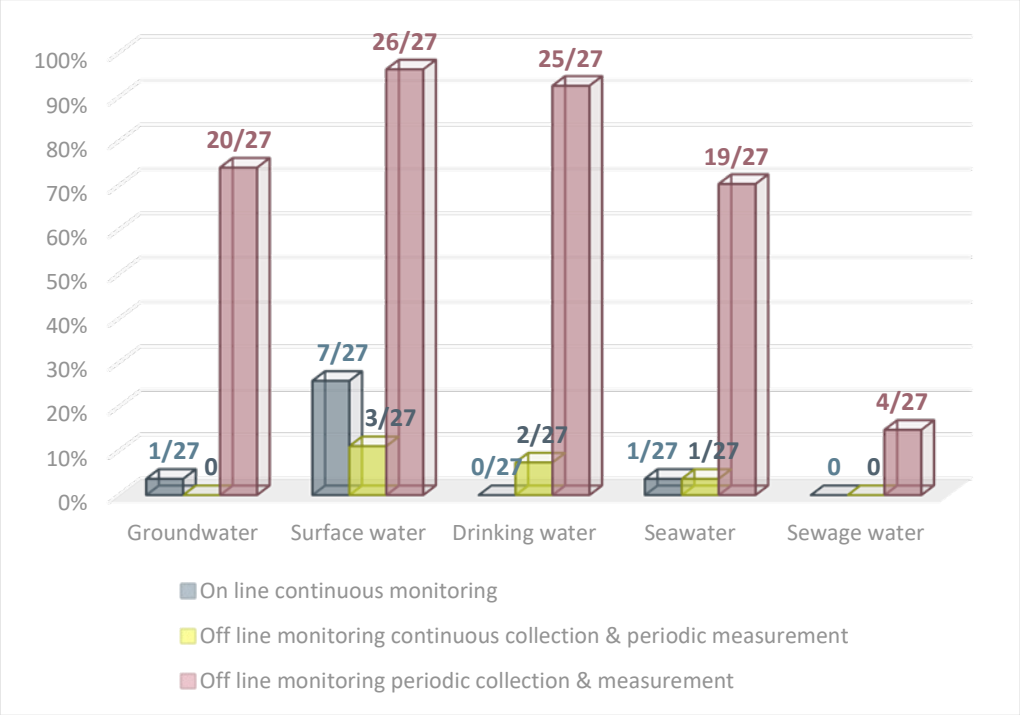

Figure 18: Water monitoring in EU MS.[3]

Food, vegetation and soil medias are monitored in the EU MS through the collection of periodic samples followed by radioactivity analyses in laboratories. The different media collected in the 27 EU MS are presented in figures 19a-c.

Regarding food items monitored:

- Milk is analyzed in all EU MS;
- Meat is not monitored in Malta, Greece and Sweden;
- Fish is not monitored in Greece and Malta;
- Mixed-diet is not monitored in France;
- Other foodstuffs are monitored in 25/27 countries. It concerns for instance the monitoring of honey, eggs, mushrooms, reindeer and other food items specific to local consumption.

Sediments in river and/or sea are monitored in 22/27 EU MS (no monitoring reported in Croatia, Finland, Greece, Malta and Slovenia). Uncultivated soils are more commonly monitored in EU MS (21/27) than cultivated soils (9/27) (see figure 19b). Austria, Belgium, Germany, Hungary, Italy and Portugal are the only countries reporting the monitoring of all soil items.

Regarding the monitoring of vegetation items, at least one vegetation item is monitored in 24/27 EU MS. Vegetation is not reported being routinely monitored in Malta, Greece. Finland reports only the monitoring of wild plants and other natural products. Sweden mentions only the monitoring of aquatic biota.

[3] Malta does not have surface water on their territory. It explains why the chart goes up to 96% instead of 100% for surface water monitoring.

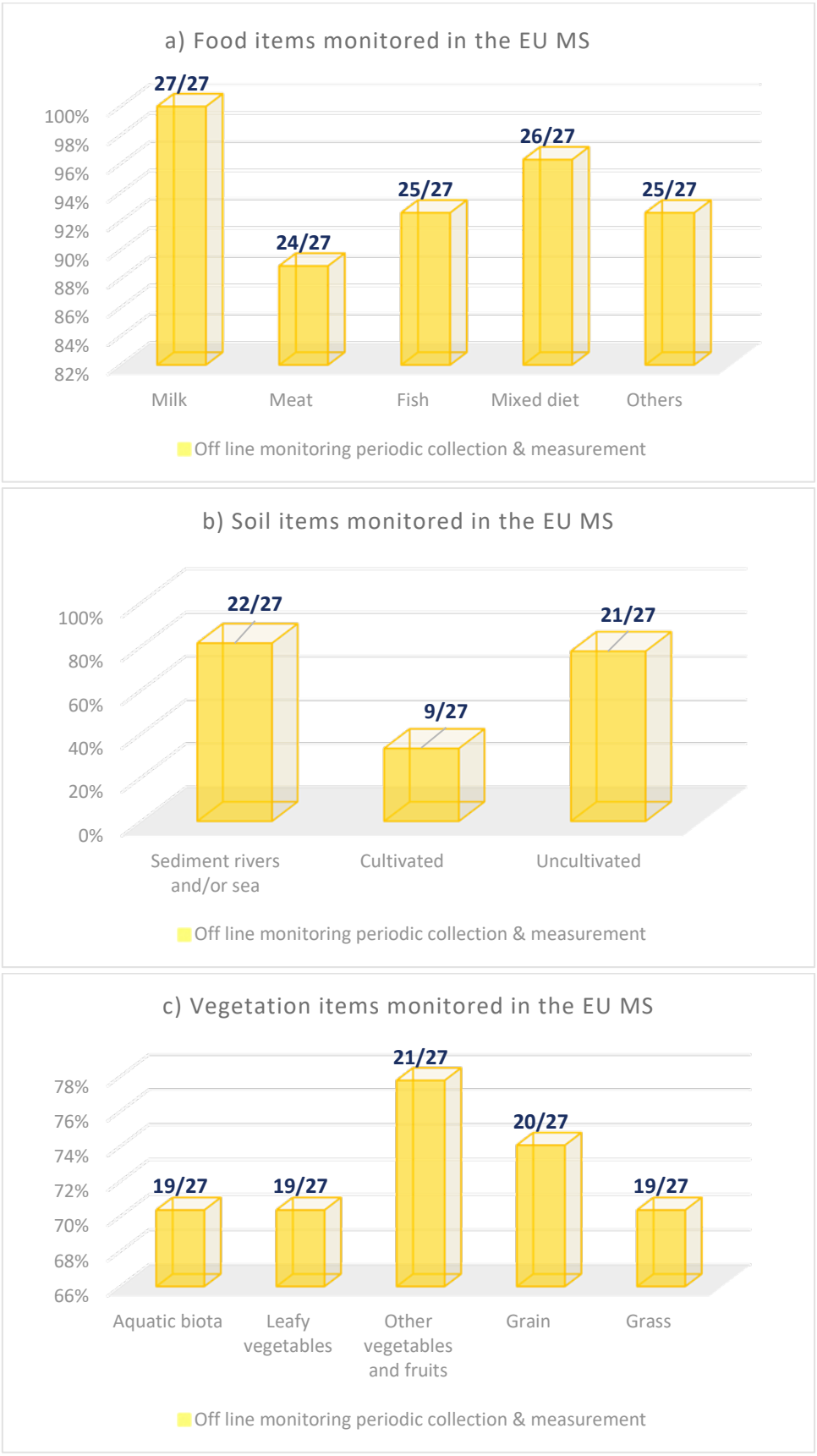

Figure 19: Items monitored in EU MS in a) food, b) soil and c) vegetation.

3.3.3. Information to the public

In normal situations, the four main types of organizations in the EU MS providing information to the public on radiological monitoring programs are:

- The nuclear regulatory body;
- The Public health authorities;
- The environmental protection authorities;
- The operators of facilities discharging radioactivity in the environment.

In emergency situations, local and regional administrations as well as emergency response organizations take over partly the responsibility to communicate with the public (figure 20).

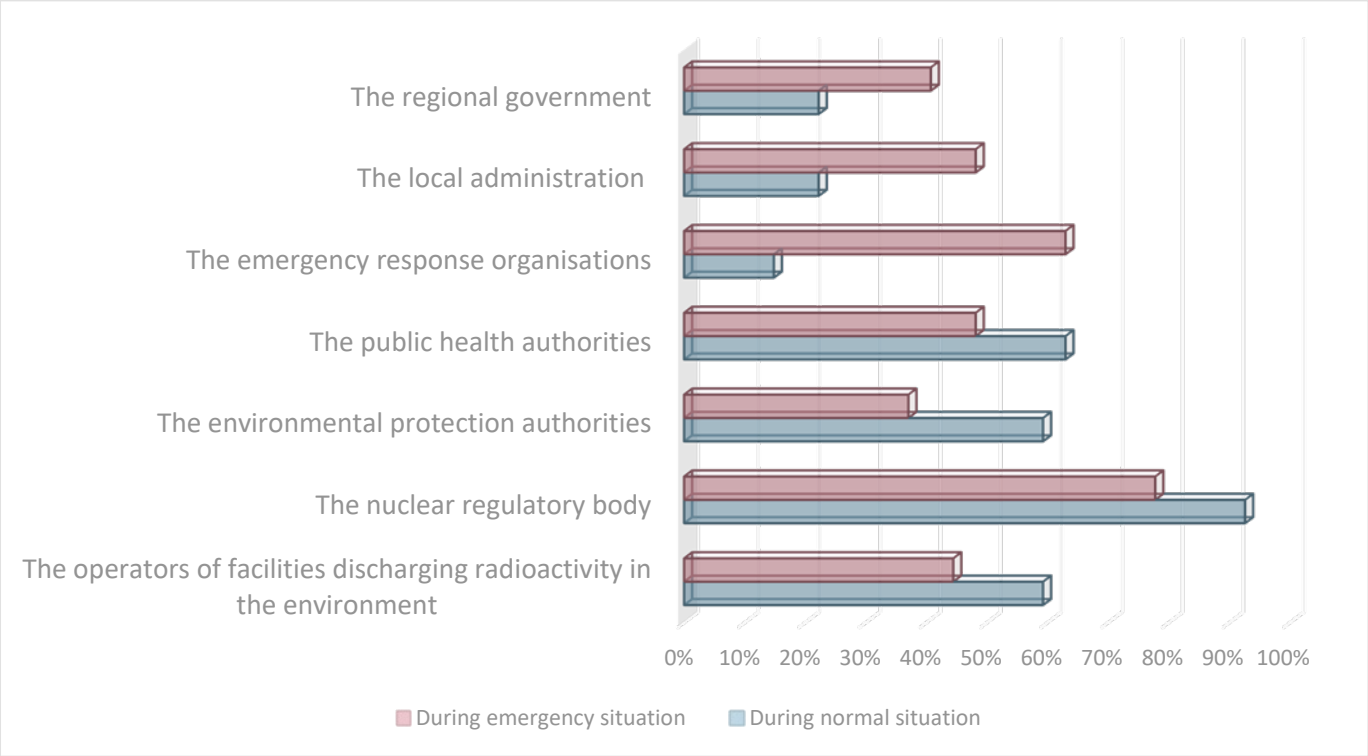

Figure 20: Types of organizations responsible for informing the public in the EU MS.

The type of information provided to the public in normal and emergency situations are summarized in figure 21. They are similar in the different EU MS.

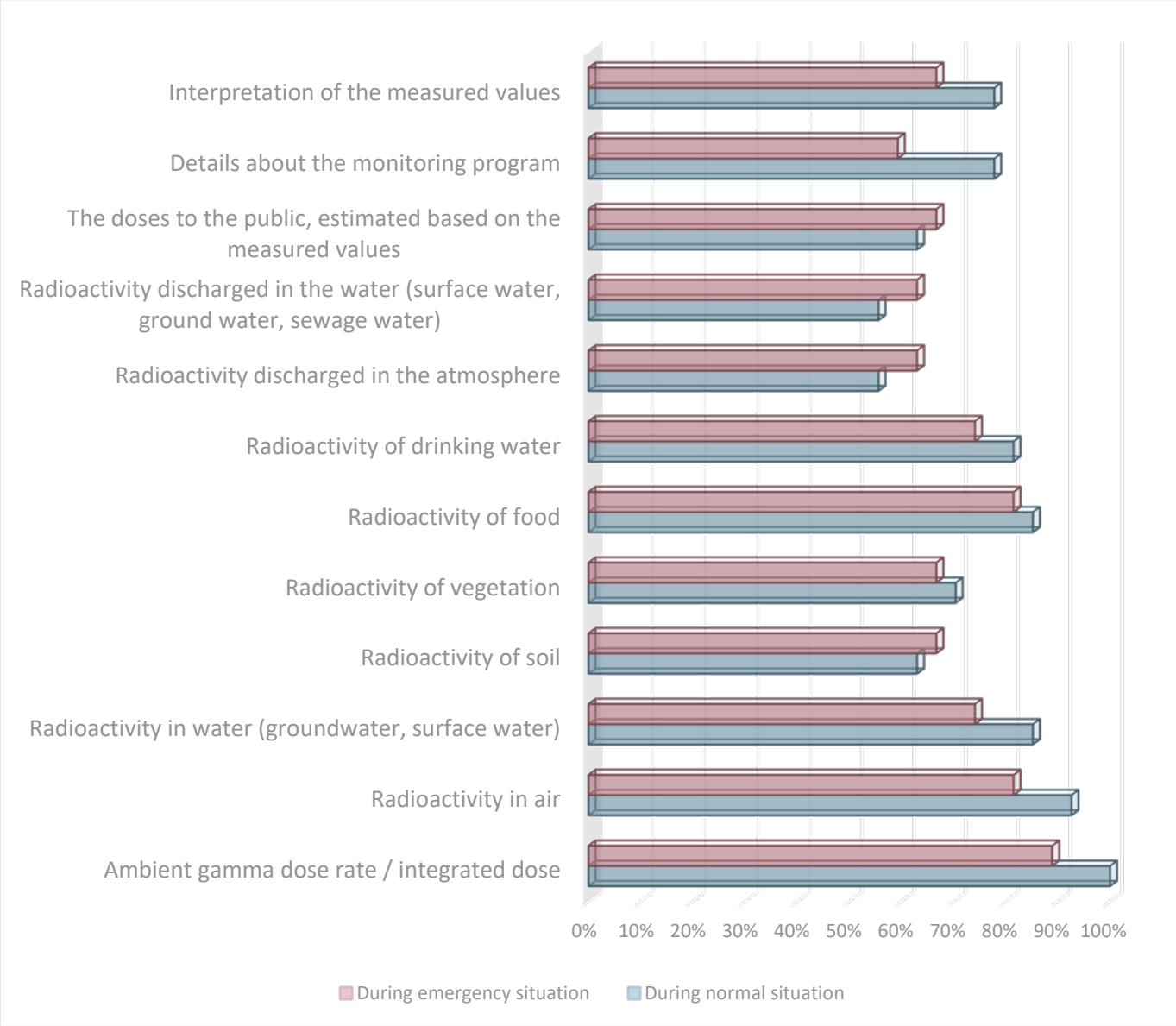

Figure 21: Type of monitoring data communicated to the public in EU MS in normal and emergency situations.

In normal and emergency situations, information on ambient gamma dose are communicated to the public in majority via on-line web-based platforms available on the website of official authorities (nuclear regulatory bodies, environmental radiation protection authorities, EURDEP platform, for instance). The information is either made available in real-time or with a certain periodicity.

Details on monitoring programs and their results in normal circumstances are commonly published on periodic reports emanating from the different EU MS authorities and organizations responsible for organizing the monitoring programs (public health and environmental authorities, nuclear regulatory bodies, radiation protection authorities).

During emergency situations, communication to the public is made mainly on-line on authorities' websites (20/27) and using traditional medias such as radio and TV channels (18/27). Social medias are used only in 14/27 of the EU MS in emergency situations. The use of this communication way drops to 9/27 in normal situations (figure 22).

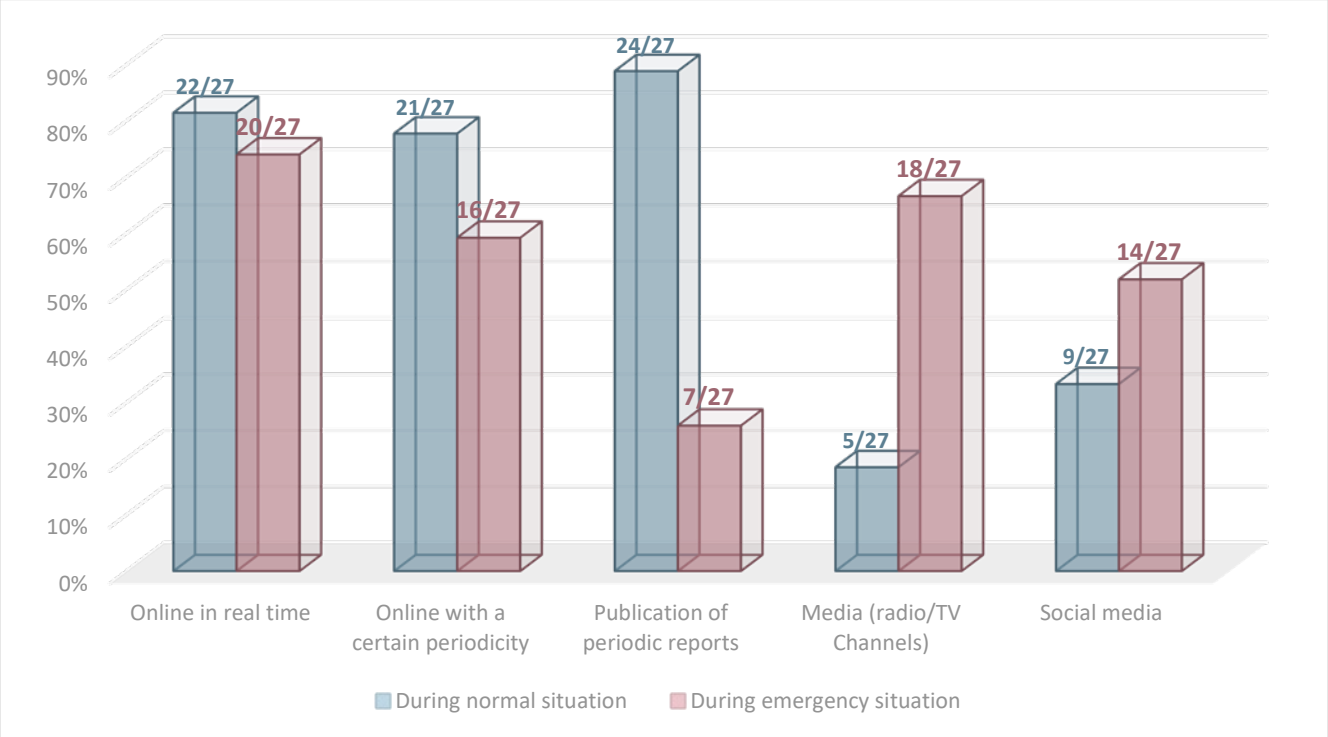

Figure 22: Main communication ways used in EU MS for informing the public on radiological monitoring in normal and emergency situations.

3.4. Main observations on monitoring programs implemented in the EU MS and key recommendations

In general, the monitoring programs implemented in the EU MS are well-developed and adapted to the country profiles. The next table summarizes the main weaknesses and best practices observed in the frame of this study.

Main recommendations provided on each EU MS monitoring programs are available in their national reports.

Table 2: Main weaknesses and best practices observed among the EU MS monitoring programs.

Main weaknesses observed	Best practices observed
• Lack of capabilities to monitor gaseous iodine in air which does not allow tracing back the origin of iodine puff detected in Europe. • Limited monitoring of radioactivity in individual foodstuffs can lead to limited representation in the monitoring program of the population consumption. • Sampling points should cover the entire territory of a country. • Lack of well-defined emergency monitoring programs. No emergency procedures/plans/programs in place could lead to difficulties in the coordination of the monitoring/measurement tasks and delay the appropriate response. • Lack of human resources capable of running the national environmental monitoring program.	• Development of specific monitoring projects by screening alpha, beta and gamma emitters using measurements with low limit of detection for specific radionuclides in determined medias. Based on the results of the projects and the corresponding risk assessment, development of a monitoring program for the determined medias according to the associated risk. • Working with LLD values different in routine circumstances and emergencies (risk graded approach). • Performance of independent verification initiated by country's authorities of the environmental monitoring programs developed by operators. The verification is carried out by independent laboratories.

• Authorities not being aware of the laboratories' measurement capabilities. This could be critical in case of emergency situations. • No detailed information about the monitoring programs in place communicated to the public. • Having a monitoring program relying on measurements performed mainly by foreign laboratories. It results in a lack of capacities and competencies in case of emergencies.	• Having only one authority in charge of environmental, drinking water and food radioactivity monitoring. In this way, there are no overlaps or gaps that could easily appear when numerous organizations are involved and conducting only parts of a national program. • Having one national authority holding the responsibility of operating the on-line monitoring system while the laboratory measurements are done externally by accredited laboratories. • Measurement of Sr-90, Pu and U isotopes in most of media in routine situation. It results that the "usual" activity concentration is known and additional input can be easily recognized. • Radon monitoring devices available in most of laboratories involved in the environmental monitoring programs of a country. • Having the same laboratories performing measurements in normal and emergency situations. • Measurements of the monitoring programs performed by ISO 17025 accredited laboratories. • Development of working procedures issued by the nuclear regulatory body is a good way for guaranteeing the harmonization of the measurement methods in application in the laboratories involved in monitoring programs. • Having air-samplers across a territory and equipped with charcoal cartridge and spectrometric capabilities for gaseous iodine measurements.

Based on the information collected in the frame of the study, the following general recommendations could be considered to further improve the existing monitoring programs implemented in the EU MS:

- Adapt the sampling/measurement frequencies of the media monitored to be, at minima, in line with the Commission Recommendation 2000/473/Euratom;
- Adapt the radionuclides to be monitored in the different media listed in the annex 1 of EC recommendations. Non-mandatory measurements (gross β in airborne particulates (not needed if gamma spectrometry measurements done), β residual in surface water and C-14 in mixed-diet and foodstuffs) should be considered too;
- Perform a critical analysis, considering the staffing of the different laboratories, the availability of their measurement capabilities, for responding to emergencies;
- Develop radiological emergency monitoring programs if not already in place;
- Develop capabilities to measure gaseous iodine if not already available;
- Develop websites or database allowing access to geo-referenced measurement data of the off-line programs in a user-friendly manner, comparable to what is being done for on-line measurements. This should enhance the confidence of the public.

4. 2000/473/Euratom compliance overview

The analysis of each EU MS monitoring system was carried out based on the information collected and by confronting it with the Commission Recommendation 2000/473/Euratom.

The table 3 represents an overview of the compliance status of the 27 EU MS against the Commission recommendation.

Based on this analysis, it can be seen that on overall only 7/27 of the EU MS are fully compliant with the EC recommendation.

More specifically, regarding the measurement categories:

- All EU MS are compliant for the monitoring of airborne particulates and air, meaning that they monitor at least Cs-137 and Be-7 in airborne particulates and ambient gamma dose rate;
- 25/26 of the EU MS are compliant for the monitoring of surface water (Malta being excluded as there is no surface water in their country) – Cs-137 is being not monitored as recommended in only one country;
- 23/27 of the EU MS are compliant for the monitoring of milk and mixed-diet. Countries being not compliant with the recommendation, do not analyzed K-40 or Sr-90.

25/27 of the EU MS have laboratories involved in their monitoring program participating in intercomparison exercises.

3/27 of the EU MS do not comply with the EC recommendation regarding the radionuclides to be monitored in drinking water. However, this information should be not be considered as the new legal situation in EU MS on drinking water for human consumption is the Council Directive 2013/51.[4]

15/27 of the EU MS comply with the EC recommendation for radionuclides to be monitored in foodstuffs as 12/27 of EU MS do not measure Sr-90 in these types of samples or there is no monitoring program in place for measuring radioactivity in individual foodstuffs.

As for the monitoring periodicity criteria:

- Airborne particulates are sampled using continuous sampling in all EU MS;
- Air is monitored continuously in all EU MS;
- 15/26 of EU MS are compliant with the measurement frequency of surface water (Malta being excluded as there is no surface water in the country)
- 15/27 of EU MS are compliant with the measurement frequency of mixed-diet samples;
- 20/27 of EU MS collect and perform measurements on milk samples with the frequencies recommended.

Although the measurements of gross β in airborne particulates, β residual in surface water and C-14 in mixed-diet and foodstuffs are not mandatory as stated in the EC recommendation 2000/473/Euratom: “where measurements are recorded, they should be reported”, the analysis performed shows that:

- 15/27 of EU MS perform gross beta measurement on aerosols;
- 10/26 of EU MS measure β residual activity in surface water (Malta being excluded as there is no surface water in the country);

[4] EU MS compliance study with the Directive 20163/51 is out of the scope of the study reported here and is part of the project ENER/D3/2016-675.

- 2/27 of EU MS carry out C-14 analysis in mixed diet;
- 3/27 of EU MS carry out C-14 analysis in foodstuffs samples.

Table 3: Overview of the compliance status of the 27 EU MS against the EC recommendation 2000/473/Euratom

Measurement categories	2000/473/Euratom	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	%
Airborne particulates	Cs-137, Be-7, gross β*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	100%
Air	Ambient gamma dose rate	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	100%
Surface water	Cs-137, β residual*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NA	●	●	●	●	●	●	●	●	96%
Milk	Cs-137, Sr-90, K-40	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	85%
Mixed-diet	Cs-137, Sr-90, C-14*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	85%
Laboratories participating in intercomparison exercise		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	93%

Measurement periodicity	2000/473/Euratom	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	%
Airborne particulates	Continuous sampling	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	100%
Air	Continuously	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	100%
Surface water	Monthly/Quarterly	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NA	●	●	●	●	●	●	●	●	58%
Milk	Monthly/Quarterly	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	74%
Mixed-diet	Not less than quarterly	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	56%

	2000/473/Euratom	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	%
Drinking water	H-3, Sr-90, Cs-137	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	89%
DWM specifications	From major ground/surface water supplies and/or distribution networks	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	96%
Foodstuffs	Gamma emitters, Sr-90, C-14*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	56%
FM specifications	Separate ingredients from market places, local distribution centres	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	96%

	AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	DE	GR	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE	
Country compliance	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✗	✓	✗	✗	✗	✓	✗	26%

	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	%
Gross beta in airbrone particulates	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	56%
Beta residual in surface water	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NA	●	●	●	●	●	●	●	●	38%
C-14 in mixed-diet	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	7%
C-14 in foodstuffs	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	11%

5. Comments on the Commission Recommendation 2000/473/Euratom

As mentioned earlier in this report, it appears that the Commission Recommendation 2000/473/Euratom is not mentioned by the EU MS as a document of reference for the development of their monitoring programs. This might be explained by the fact that the recommendation is outdated (21 years old) and was developed as an outcome of the Chernobyl accident by focusing mainly on the monitoring of Cs-137. With this consideration the Commission Recommendation is not in-line with the monitoring challenges faced by the EU MS current situations.

The main comments from the MS regarding the recommendation are as follows:

- The recommendation is unclear and gives too much room for interpretation. Consequently, it does not allow a good harmonization of monitoring practices between the different EU MS;
- The overall aim of the recommendation is not described precisely. Is it to perform environmental monitoring for collecting data on radioactivity levels in EU MS? Is it for determining the exposure of the population as a whole or in specific locations close to nuclear facilities? A revised recommendation should answer this general interrogation and provide well-defined guidelines;
- The concept of sparse/dense networks as well as regional distinctions are quite different among the EU MS. It is not easily applicable for all EU MS and might not be considered/relevant;
- The recommendation does not include the new monitoring challenges that EU MS are facing such as the monitoring of NORM industries;
- Some parameters required to be monitored in various environment matrices might not be appropriate to local situations. An updated recommendation should take the EU MS specificities into consideration for developing better, costs effective and more efficient monitoring programs.

More specific comments provided by the MS mainly dealt with foodstuff and NORM monitoring.

- On foodstuff monitoring:
    - The special role of milk monitoring could be studied. In nuclear accidents, iodine contamination in milk can be a major dose contributor and especially relevant for children. Prompt monitoring of milk is necessary in these cases. However, with current levels of environmental contamination, the monitoring results from past years have shown that milk is not a major contributor to the dose of the population. Current recommendation for a frequent sampling and individual reporting might not be justified and those resources could be used better in other monitoring activities. Investigation if milk could be included as part of the mixed diet monitoring, to be reported as an individual ingredient or as part of complete meals;
    - Proposition for the Recommendation modification: Mixed diet replacement by primary foodstuff production. Radionuclides list evolution (35 years after Chernobyl);
    - With respect to the mixed diet sampling, the recommendation indicates that, when appropriate, separate ingredients that come from crops or productions in the area should be taken and analyzed in order to measure local or regional radioactive contamination instead of having an estimation of the impact that the public receives. Further clarification and harmonization may be desirable, considering that so far there is a significant amount of results and data for each option, that can be assessed;
    - The Commission should work together with other international organizations in measuring radionuclides in food and drinking water in non-emergency situations, such as the IAEA, which is currently developing work on this topic;

- On NORM Monitoring:
    - Considering the possibility of including natural radioisotopes in the Recommendation in order to obtain background data to be used when assessing results around NORM industries, uranium mines, etc. Additionally, Pu-239 could also be included to characterize the plutonium in fallout;
    - Evaluate the contribution from natural radionuclides to the dose received by the population. For this purpose, the natural radionuclides (NORM) such as U-238, U234, Ra-226, Ra-228, Pb-210 and Po-210, must be analyzed in a future program in the different pathways, aerosols, mix diet, tap water and milk.

Furthermore, as part of the 2-day WS organization, the following question was asked to the EU MS representatives for receiving their feedback on the commission recommendation: *"Regarding the Commission Recommendation 2000/473/Euratom, if it would need to be revised/modified in the near future what would be your modification proposal?"*. The table provided in annex 1 lists the answers sent by the EU MS in response to it and the minutes of the workshop reflect the discussion on this topic.

Based on the EU MS's comments and the discussion during the workshop, the Contractor would recommend considering the following aspects for the discussion within the Article 35 experts' group for the possible updating of the Recommendation 2000/473/Euratom:

- The primary objective of the recommendation should be clearly defined;
- The approach should allow for flexibility allowing each MS to develop a monitoring programme adapted to the country situation;
- The monitoring program should be justified by MS explaining what is monitored (media, radionuclides, frequencies) and for which purposes.

In order to harmonize monitoring practices among the EU MS, the development of a "monitoring directive" could be an effective tool. However, it requires a long process and might lack of flexibility in its implementation resulting in requiring to some EU MS to monitor specific parameters not relevant for their specific situation. With this in mind, the development of a "modernized" recommendation could be a more convenient and effective instrument. It would also allow more flexibility in its implementation process. The revised document could/should:

- Be compared against other regulations in force (e.g. Basic Safety Standards Directive, 2013/51/Euratom Directive) to verify coherence;
- Be developed as part of discussions and negotiation between EU MS experts in the monitoring and measurements areas for considering the best practices and each EU MS specifications;
- Be objectives driven: what to monitor (radionuclides, media, matrices) and for which purposes. It should be supported by a well-defined scope to avoid misinterpretation;
- Be adapted to the new concerns of the EU MS: monitoring of NORM, source-related monitoring (in opposition to the current recommendation which focuses on the monitoring of Cs-137 in reaction to the Chernobyl accident);
- Act as monitoring guidelines in terms of good practices, methodologies, protocols, sampling frequencies, equipment, etc.;
- Consider particularities and variations among the different EU MS for allowing flexibility in its implementation by the EU MS according to their national circumstances and particular needs. To do so, a justification process could be suitable. For instance, if there are parameters not monitored, justification of not monitoring these parameters should be a possibility offered to the EU MS based on their typical profile and well-defined criteria;

6. Needs for development for the period of 2021 – 2030

As part of the 2-day WS organization, the following question was asked to the EU MS representatives for receiving their feedback on the development planned in their country: *"Are there any major changes and/or needs for development planned in the environmental radioactivity monitoring systems in your country for the period 2022 – 2030?"*. The table in annex 2 summarizes the answers sent by the EU MS in response to this interrogation. The main topics mentioned to be developed in the next ten years in the EU MS are, as follows:[5]

- Expansion, renewal and/or modernization of on-line monitoring systems are planned in 14/27 of EU MS (Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, Poland, Romania, Slovenia and Sweden);
- Update/revision of off-line monitoring programs in 6/27 of EU MS (France, Ireland, Portugal, Cyprus, Finland and Spain);
- Update/revision of regulation in force in 6/27 of EU MS (Bulgaria, Luxembourg, Poland, Slovenia, Spain and Sweden);
- Development of better communication to the Public in 5/27 or EU MS (Ireland, Austria, Portugal, Spain and Sweden);
- Development of emergency procedures/plan/equipment in 4/27 of EU MS (Finland, Lithuania, Portugal and Sweden);
- Pursuing laboratories accreditations processes in 3/27 EU MS (France, Italy and Spain);
- Development of tools for the management of monitoring data in 2/27 of EU MS (Poland and Lithuania).

According to the Contractor, other needs for development that should considered are:

- Harmonization of equipment/technology used for on-line monitoring to collect similar data and smooth the exchange of information between EU MS;
- Adoption of the use of drones equipped with monitoring equipment in case of emergency situations;
- Development of methodologies considering sampling uncertainties as part of the analysis of monitoring measurements;
- Development of detailed guidelines for harmonizing among EU MS sampling, frequencies and analytical methods;
- Use of artificial intelligence as support to authorities for the treatment and analysis of monitoring data;
- Development of tools/procedures for communicating monitoring program to the public in user-friendly ways. Social media should be more commonly used for communicating to the public the purpose of radioactivity monitoring and for educating the public to its importance;
- Development of a center of excellence for radioactivity monitoring in charge of maintaining competences at the EU level. This center of excellence could be also an international training center for improving the monitoring capabilities and spread best practices on the international level;
- Development at the European scale of an on-line automatic network for the early detection of iodine release in the atmosphere. This network could be a combination of stations owned by EU MS and by the EC (JRC).

[5] No major/specific developments were notified by 8/27 EU MS (Croatia, Denmark, Estonia, Latvia, Malta, The Netherlands, The Slovak Republic and the Czech Republic.

7. Conclusion and recommendation

This concluding report is the result of a 34-months project[6] developed by a Consortium (IRE – project leader, Belgium), SCK•CEN (Belgium), AGES (Austria), ENCO (Austria) in charge of its implementation and thanks to the cooperation of the EU MS Art. 35 contact persons who helped in providing information on the monitoring programs in force in their respective country. The project was developed with the support of the Directorate-General for Energy of the European Commission.

The study has allowed to draw a cartography of the radioactivity monitoring situation at the EU level. It has also provided the possibility for the EU MS to get a detailed overview of their national monitoring arrangements in routine and emergency situations as depicted in their national reports. The analysis performed on each EU MS monitoring program has given the chance to highlight best practices as well as the needs for improvement and weaknesses. The results of this evaluation should enable the EU MS for taking actions in order to update their monitoring programs based on the proposed recommendations.

All information collected on EU MS monitoring programs have been stored in a web-based database built as part of the project development. This database should be used in the future for updating information on EU MS programs in the frame of Art.35 verification missions. For updating the information available in the database, it is recommended to apply four levels of user access, as follows:

- Public users with read-only access to publicly available information;
- Country-specific user (operators) with privileges to enter and update country specific information only;
- Country-specific administrators with full access to a country data and management of country-specific users;
- Database administrator with full access to data on any country and management of any user.

It is also recommended that the database administrators (EC) develop a register (GDRP compliant) dedicated to keep traces of information on the contact persons with country-specific users and country-specific administrators accesses for controlling the number persons using the database.

As a general conclusion, although only 7 out of 27 EU MS are fully compliant with the Commission Recommendation 2000/473/Euratom, the EU MS have developed both on-line and off-line monitoring programs which are adapted to their country profile. It should also be pointed out that there is a lack of harmonization in the monitoring practices implemented among the EU MS. To answer this issue, it is recommended to develop at the EU level a modernized recommendation providing detailed guidelines in terms of good practices, methodologies, protocols, sampling frequencies, equipment, etc., and acting as a document of reference from which each EU MS monitoring programs could be based on and apply what is recommended based on their national situations.

8. Annexes

- Annex 1 – EU MS comments on the Commission Recommendation 2000/473/Euratom
- Annex 2 – EU MS development planned for the period of 2022 – 2030

[6] Initially a 2-year project which was extended to 34 months due to the covid-19 pandemic.

Annex 1 - EU MS comments on the Commission Recommendation 2000/473/Euratom.

EU MS	Comments
Austria	• The aim of the determinations should be described more precisely. Is it environmental monitoring or the determination of the exposure of the population as a whole? (e.g. mixed diet from a canteen is not environmental monitoring but it is a good determination of the exposure of the public); • The execution of the determinations or the assumptions of the calculations should be described more precisely. (e.g. mixed diet Bq/person/day how much kg/day is defined, or more information about air measurements (wet, dry deposition, filter sampling)).
Belgium	• No specific comments.
Bulgaria	• No specific comments.
Croatia	• No specific comments.
Cyprus	• Although Cyprus does not identify any particular difficulty in applying the recommendations of the EC, it is of the opinion that the Recommendation 2000/473/Euratom should be supported by guidelines for further harmonizing the environmental radioactivity monitoring across Europe (in terms of methodologies, protocols, frequencies, equipment, etc.), considering particularities and variations among the different Member States, allowing however some extent of flexibility to Member States according to the national circumstances and their particular needs.
Czech Republic	• Use web services instead of SFTP (Secure File Transfer Protocol) for international data exchange due to higher level of cyber security.
Denmark	• No specific comments.
Estonia	• The recommendation should be modernized (on automatic networks and other modern solutions which are now widely used in most of the EU MS)
Finland	• The Recommendation should be compared against new legislation (e.g. Basic Safety Standards Directive, COUNCIL DIRECTIVE 2013/51/EURATOM laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption) to verify coherence; • The special role of milk monitoring could be studied. In nuclear accidents milk iodine contamination can be a major dose contributor and especially relevant for children. Prompt monitoring of milk is necessary in these cases. However, with current levels of environmental contamination, the monitoring results from past years have shown that milk is not a major contributor to the dose of the population. Current recommendation for a frequent sampling and individual reporting might not be justified and those resources could be used better in other monitoring activities. We propose to investigate if milk could be included as part of the mixed diet monitoring, to be reported as an individual ingredient or as part of complete meals. For source monitoring purposes different justification exits and we are commenting here only national level monitoring activities not tied to a particular source; • The frequencies of surface water monitoring and foodstuff monitoring could be also revised and member states given more room to select sampling frequencies based on local conditions and local nuclear activities.
France	• Proposition for the Recommendation modification: Mixed diet replacement by primary foodstuff production. Radionuclides list evolution (35 years after Chernobyl).
Germany	• A revised recommendation should no longer concentrate on Cs-137 and Sr-90 but include other radionuclides resulting from planned or existing exposure situations which may be relevant for the radiation exposure of members of the public.
Greece	• No specific comments.
Hungary	• We have actually no suggestion to revision of 2000/473/Euratom; • Maybe the communication of abnormal observation could be included into the Recommendation, however it is partly linked to emergency communications (See HERCA position Paper on "Sharing Actively Information among Competent Authorities in case of Abnormal Observations").
Ireland	• Some of the parameters required to be monitored in various environment matrices are not appropriate to Ireland as there are no significant sources of artificial radiation on the island of Ireland. Evidence for this has been demonstrated by previous studies in various environment matrices.
Italy	• A modification proposal could concern the definition of detection limits for the sparse network considering both typical instrument sensitivity and relevance from the point of view of radiation protection. In the sparse network the measurements should be quantified, actually this requirement is not easy to fulfill, due to the lower and lower levels of radioactivity (namely Cs-137).
Latvia	• No specific comments.
Lithuania	• No specific comments.

Luxembourg	• Comments on the following articles of the recommendation:
	  ○ (9): “Experience has shown that the incorporation of soil data in the monitoring serves little useful purposes” = Does it means that this monitoring is not significant?
	  ○ 4.(b) (ii): “detection limits and sensitivities should allow the actual levels to be quantified “= it is not always meaningful. It depends on the level.
	  ○ 4.(c) (iii): “the average flow rate during the sampling period should be reported” = not reported.

	○ 4.(c) (iv) “corresponding volumes of water distributed or produced should be reported” = not reported. ○ 4.(c) (v) “Milk samples should be taken from dairies” = LU: from 3 farms and not statistical information on production rates provided. • Annex IV: NUTS-code = obsolete • Reference date = sampling date? • Residual beta activity/ an explanation concerning the calculations should be given to the MS when the activities are determined via two different measurements methods => combine uncertainties? What is the situation when the results are below the detection limits?
Malta	• No specific comments.
The Netherlands	• No specific comments.
Poland	• No specific comments
Portugal	• In a revised proposal, the European Commission understanding for what must be mandatory or just good practices must be very clear. For example, it is not our understanding that emergency monitoring capabilities should be addressed under the art. 35 and 36. It is fundamental to evaluate the contribution from natural radionuclides to the dose received by the population. For this purpose, the natural radionuclides such as U-238, U234, Ra-226, Ra-228, Pb-210 and Po-210, must be analyzed in a future program in the different pathways, aerosols, mix diet, tap water and milk. • Other issue which needs clarification is related to sampling location and the representability to the dose received by the population.
Romania	• From the Radiation Hygiene Laboratories network: it is not very clear which are the specific actions needed if measured values exceed reporting levels and which are the measures in case of detection limits exceed reporting levels? • From NERSN: No specific comments.
Slovakia	• No specific comments.
Slovenia	• The concepts of sparse/dense networks as well as regional distinctions are quite different for larger or smaller countries and may not be easily applicable for all MS. • The regional definitions in Annex II should reflect the current situation of be left out with the link to the more up to date source.
Spain	• Regarding food monitoring, Spain considers that the Commission recommendation should work together with other international organizations in measuring radionuclides in food and drinking water in non-emergency situations, such as the IAEA, which is currently developing work in this topic. • With respect to the mixed diet sampling, the recommendation indicates that, when appropriate, separate ingredients that come from crops or productions in the area should be taken and analyzed in order to measure local or regional radioactive contamination instead of having an estimation of the impact that the public receives. Further clarification and harmonization may be desirable, considering that so far there is a significant amount of results and data for each option, that can be assessed. • As drinking water is one of the samples monitored within the Commission recommendation, it should be updated based on the provisions of Directive 2013/51/Euratom (DWD – Drinking Water Directive). • We suggest to consider the possibility of including natural radioisotopes in the Recommendation in order to obtain background data to be used when assessing results around NORM industries, uranium mines, etc. Additionally, Pu-239 could also be included to characterize the plutonium in fallout.
Sweden	• Developing a new discussion on the scope of art 35/36 and the recommendations and how this affects the recommendations. How do the MS look at monitoring around nuclear facilities in relation to the” population as a whole” for example. What are the aims of the monitoring under art35/36 and the populations as a whole? It should give a broad picture of the general situation and long-term trends. It is mainly not suitable to assess doses to representative person or to give quick information of sudden changes in order to detect unknown releases (except gamma stations and in part air filter stations which work this way, although they are, in practice, more an emergency preparedness system where data of air filter stations are reported (at a late stage) the same way as the other data while gamma station data are reported more on-line to the commission within EURDEP). • The needed frequencies in this monitoring might be discussed further. • A discussion on NORM would be interesting. But again, it is important to think of the aim of such monitoring in respect to the population as a whole. There might not be any quick changes foreseen for NORM so the frequencies of such monitoring for the population as a whole would might not need to be very high (maybe coordinated one-off surveys also could be discussed). • How should drinking water quality be reported to the commission? There is already in place a reporting system for water quality for other parameters, should/could radioactive parameters be included there? What are the expectations on reporting according to art35/36 and REM database in this respect? All measurements from all water plants, or a small representative subset? There are some parameters that very few countries report, one could discuss the reasons and how the recommendation should handle this in the future.

Annex 2 - EU MS development planned for the period of 2022 – 2030.

EU MS	Development planned in EU MS for the period of 2021 - 2030
Austria	No major changes but some improvements are planned: • Expansion of the air monitoring system with additional high-volume samplers and iodine sampling; • More information to the public by additional homepage articles; • Modernization of the AMS Monitoring Stations.

Belgium	Major changes are planned for the period 2021 – 2030 including:
	• Renewal of the on-line monitoring system TELARAD during the period 2022 – 2025 including:
	  ○ 173 air gamma dose rate stations;
	  ○ 71 spectrometric (NaI) low dose rate stations;
	  ○ 29 spectrometric ($CeBr_3$) low dose rate stations;
	  ○ 8 spectrometric high dose rate stations;
	• Replacement of the alpha and beta aerosols monitoring detectors (AER) from 2022: Currently, FANC has 7 aerosols monitors dating from 1993. FANC plans to acquire 11 new stations in order to strengthen the monitoring performed around the Belgoprocess site and the NPPs areas. The new stations will be “mobile or movable”.

Bulgaria	The Environmental Executive Agency (ExEA) under the MoEW operates 8 radiation measurement laboratories in Bulgaria (Sofia, Vratsa, Montana, Pleven, Varna, Bourgas, Stara Zagora and Plovdiv). The Environmental Radioactivity Monitoring Program includes measurements of aerosols, water (groundwater, surface water, seawater, sewage water), uncultivated soil and sediment. Upcoming activities: The off-line monitoring program for 2022 is to be updated due to: • Construction of a National Repository for disposal of short-lived low- and intermediate-level radioactive waste around Kozloduy NPP; • Update of Regulation № 1 on the limit values for the purposes of radiation protection and safety during liquidation of the consequences of the uranium industry in the Republic of Bulgaria (SG No. 101/23. 11. 1999.)
Croatia	• No specific development was notified.
Cyprus	• Cyprus plans to upgrade its existing aerosol alpha, beta, gamma and Iodine monitoring station with a HPGe detector, as well as establish high volume aerosol monitors with automated spectroscopy (NaI/LaBr3) in all 7 locations of the existing telemetric ambient gamma dose rate network; • Cyprus also plans to extend its monitoring programme to include atmospheric deposition measurements and upgrade the SGL’s measurement capabilities in measuring beta emitters such as Sr-90 and C-14 in foodstuff/mixed diet.
Czech Republic	No major changes are planned in environmental radioactivity monitoring systems (ERMS) for the period 2022-2030: • The National monitoring program is currently being updated; • Equipment for national ERMS is restored as required; • An upgrade of national monitoring database MonRaS is planned in period 2022-2030; • Currently, no new technology is considered to be applied in ERMS; • State Office for Nuclear Safety (SONS) cooperates with SÚRO laboratory. The laboratory is member of ALMERA network and follows ISO 17025. Other laboratories providing data to national monitoring database MonRaS have to participate in comparative measurements organized by SONS; • Other changes in ERMS will be based on the construction of new unit in Dukovany locality which is under consideration.
Denmark	• No specific development was notified.
Estonia	• No major changes are planned.
Finland	• Finland does not foresee any major changes in responsible authorities or in regulatory or legislative framework. National Radiation act was updated recently (2018), implementing e.g. the Basic Safety Standards Directive. • On-line external dose rate monitoring network is planned to undergo a renewal, where existing stations are replaced with new ones. Station locations and the number of stations is expected to stay unchanged. The network will still use current GM-sensor based technology for measuring the dose rate. Finland’s national environmental radioactivity monitoring program is evaluated and developed continuously. At this point, Finland does not foresee any major changes. Monitoring data is made available to the public in real time and this practice will continue in the future. • Existing procedures for emergency situations will be developed continuously but no major changes are expected. National radiation emergency monitoring strategy is in publication process, some development needs will come from the strategy. • Cross border monitoring is conducted jointly with Customs authority.

France	• For the IRSN:
	  ○ Gamma spectrometry probes and passive sampling (H-3) ongoing implementation near facilities.
	  ○ Organization of C-14 passive sampling studies.
	• Regarding SCL, all its laboratories will be accredited with extension in FLEX 3.

Germany	• The regulatory framework, especially the Guideline concerning Emission and Immission Monitoring of Nuclear Installations (REI) and the General Administrative Provision on the Integrated Measurement and Information System for Monitoring Radioactivity in the Environment (AVV-IMIS), is in revision. This is caused primarily by an adaptation to the Radiation Protection Act and the Radiation Protection Ordinance. Furthermore, experiences with the practical application of the regulatory framework enter into the revision. Concerning the remote monitoring of nuclear power plants, e. g. measurement of gamma dose rates, the requirements are adapted to the progress of decommissioning and dismantling of the facilities. • Some of the monitoring systems will be renewed and further developed, e. g. with respect to automatization, but there will be no fundamental change.
Greece	As part of the environmental radioactivity monitoring programme, EEAE operates a telemetric network consisting of 24 gamma-radiation-dose monitoring stations and 3 aerosol monitoring stations throughout the country. The initial aim of the network was to ensure prompt identification and notification of a nuclear or radiological emergency, particularly for reactor emergencies that may occur in a third country. Besides that, the radiation detectors and other hardware of the network are rather aged, as the installation of the system dates back to 2000. According to the current trends in nuclear emergency response, a dense telemetric network is a valuable tool for decision making under emergency circumstances. Indeed, most recent international guidelines and standards set the criteria for the prompt implementation of protective actions and other response actions on the basis of readily available monitoring data. Measures like home sheltering, restrictions in food, milk or drinking water might need to be taken, and thus, sound decision making is essential given the pronounced socioeconomic impact of such measures. This can be accomplished by the telemetric network to be used not only as an early notification tool, but also as a real-time data provider in the decision making for protective actions. • In order to face the above challenges regarding efficient management of radiological emergency situations EEAE has already planned the upgrade and extension of the existing telemetric network to be able to provide direct measures that could significantly consolidate the decision-making process in emergency response. The upgrade and extension of the existing telemetric network will consist of an adequate number of new stations (about 40), possible replacement of the radiation detectors within the existing stations, as well as of the acquisition of a small number (about 5) of air volume samplers with a possibility to sample gaseous iodine.
Hungary	Beside minor changes (e.g. development along the deficiencies noted in the national report; having been purchasing some new equipment for the laboratories), only one major change is in mind: • Establishment of monitoring systems for the new nuclear power plant (PAKS II). It means, that there will be a new operator running its own network, and the control capabilities of the responsible authorities should be enhanced (partly, since the new NPP will be next to the existing one, so some of the control measurements will be commonly used).
Ireland	• Undertake a measurement program for analysis of gamma emitters (Cs-137) in surface water; • Undertake a measurement program for analysis of C-14 in mixed-diet; • Explore the possibility of a project on gamma emitters in soil; • Explore better methods to communicate radiation monitoring data to the Irish public including dose rates from the consumption of food (dairy, fish, shellfish etc.). This may include the publication of annual reports, infographic information sheets and/or utilizing the new EPA website to better communicate such data to the Irish public.
Italy	• In the near future, ISIN will restore the National telemetric network of alarm – REMRAD, a network of automatic monitoring stations, which carries out measurements on the airborne radioactive particulates in automatic mode. The stations are located in places of particular meteorological importance due to the main incoming winds in the Italian territory. This network acts as an early warning system. In 2022 the implementation of 2 automatic stations equipped with high volume air sampling systems, and the restoration of 3 stations with lower sampling capability are planned. The target of the high-volume stations is to achieve a sensitivity of less than 10 µBq/m3 for Cs-137, for daily sampling and daily measurements; • A renewal plan of the gamma dose early-warning network, GAMMA network, has been foreseen. ISIN is, currently, substituting 17 stations with both dosimetric (9) and spectrometric (8) stations. This first batch of new probes will be installed in the sites of the network located in the north of Italy, closer to the abroad operational nuclear installation. Further batch of probes are planned to be purchased in 2022 and 2023; • In the period 2022-2030, Italy hopes to solve the critical issue of staffing capabilities both in the national authority and in the regional laboratories. In the near future ISIN has foreseen the increasing of the organic plant (staffing plan); • It is expected that most of the laboratories involved in the monitoring programs will implement quality assurance and quality control management systems and ISO 17025 accreditations.
Latvia	• No specific development was notified.
Lithuania	• The main authority involved in the monitoring of radioactivity in the environment, foodstuffs and drinking water is the Radiation Protection Centre (RPC). It is the Lithuanian regulatory body in radiation protection (=national radiation protection authority in Lithuania), responsible for setting and controlling norms for radioactive substances discharged to the environment and approving discharge plans from medical, industrial, scientific etc. enterprises. Starting on January 1st 2021 all functions related to radiological environmental monitoring were transferred to the Radiation Protection Centre from the Environmental Protection Agency and laboratory capacities of both of institutions were merged.

	• State Environmental Monitoring is performed on the basis of Program, approved by the Government. Resolution No. 996 of Government of the Republic of Lithuania of October 3, 2018 “On the Approval of the State Environmental Monitoring Program for 2018–2023”. No plans for changes of approved programs are foreseen up to 2023; • State Radiological Environmental Monitoring is carried out according Order No. V-3003 of Minister of Health of the Republic of Lithuania of December 23, 2020 “On the Approval of the Description of the Procedure for Carrying Out the State Environmental Radiological Monitoring and Providing Information to the European Commission and the Public”. No plans for changes of approved programs are foreseen up to 2023; • Laboratory of Radiation Protection Centre is accredited to the requirements of 17025 up to January 2025; • Lithuanian early warning system (RADIS) consists of 49 radiological monitoring probes for ambient gamma dose rate and spectrometric measurements. After January 2021, when administration of RADIS was forwarded from Environmental protection service to Radiation protection centre, it requires to be upgraded and adapted to new operation conditions. Within five years, Lithuania is going to replace 20 old version stations with new generation probes to ensure higher efficiency and cyber security of RADIS. It is also foreseen to relocate some 10 probes due to legal land management issues. Enhancement of connectivity service within radiological monitoring network is in progress: replacement of one provider-based service with dual provider opportunity likely to be installed in the beginning of 2022; • Under the bilateral cooperation programme with Belgium IRE, extra automatic water radiological monitoring system donated by IRE is to be installed by the end of 2021 to strengthen monitoring of the river Neris due to operation of nearby Belarus NPP; • Radiation protection centre also enhanced its capabilities in survey and detection of gamma contamination in the environment by purchasing additional mobile spectroscopic radiation detection system used for airborne and carborne radiological monitoring; • The development of GIS platform containing mobile APP for gathering, managing, analysing and sharing data collected during radiation survey is in progress involving other institutions charged to EPR. It is expected all real time data on radiological status (covering prognosis of radioactive plume arrival, ambient gamma dose rate from automated early warning system, definition of contaminated area based on airborne survey results, online result on ground-based gamma dose measurements and sampling procedures, etc.) to have summarized, viewed and managed in interactive maps and dashboards available for stockholders applying graded approach on accessibility.
Luxembourg	• No major changes are currently planned. Luxembourg will continue to implement the new legislation from 2019 following the transposition of the BSS directive.
Malta	• No specific development was notified.
The Netherlands	• No specific development was notified.
Poland	Current plans and developments are as follows: • According to the Polish Nuclear Power Program, it is necessary to extend the early warning network and to increase the number of monitoring stations; • The regulation of the Council of Ministers on monitoring programs for organizational units classified as risk categories I and II is undergoing the legislative process; • PAA develops an IT system for managing of environmental radioactivity monitoring data. The system is going to collect both on-line and off-line data, as well as to visualize and analyze it.
Portugal	• After the last Art.35 verification mission and its conclusions, it is under evaluation to redesign the off-line environmental monitoring programme. The redesign will consider: the re-evaluations of the sampling measurement frequencies, the analysis of new type of samples and to include analyses of the natural radionuclides that contribute more to the total dose such as Po-210 and Ra-226. The involvement of other national laboratories, with ISO 17025 accreditation, is under consideration for several radio-analytical parameters, in this new program; • Development of a strategy for off-line emergency monitoring that will include the arrangements for sampling (what, where, how, frequency), identifying the available analytical capabilities and human resources needed. The general provisions will be identified and more specific information will be detailed for the hazards identified in the national hazard assessment; • Working on a new way to disseminate information to public by creating a digital platform that will provide georeferenced data. It is intended to follow the French example (https://www.mesure-radioactivite.fr/en#/expert), considering that Portugal is not a nuclear country.
Romania	• The MoH laboratories network will beneficiate of measurement equipment capacity improvement as part of the national project for "Development of a national laboratory to improve the monitoring of substances discharged into water and drinking water quality" - part of Large Infrastructure Operational Plan (LIOP), Priority Axis 3 - Development of environmental infrastructure under conditions of efficient resource management. The project aims at the long-term support of a network of laboratories according to international standards by acquiring adequate laboratory infrastructure, analysis equipment necessary to monitor radioactivity indicator parameters of drinking water and implementing methods of analysis according to international standards (such as alpha spectrometry, liquid scintillation technique, high-resolution gamma spectrometry); • NESRN has apply for a project in the National recovery and resilience plan for Romania, in order to acquire new automatic gamma dose rate monitoring stations.
Slovakia	• No specific development was notified.
Slovenia	• There is an ongoing tender for the renewal of the on-line monitoring network of gamma dose rate measuring devices. The scope of the network will not change significantly, the aim is to improve the reliability, connectivity and alarming functionalities of the system. This is a 3-year project, with incremental installation of new measuring devices each year and the deployment of the complete network due in 2023; • The main legislative document concerning monitoring “Rules on radioactivity monitoring" will undergo its periodical review, with improvements based on the advances of measuring techniques and experiences collected during the last 5 years of its application.

Spain	• Within the Spanish revision process of their national basic regulations to be adapted to the European directives, new detailed provisions are to be included in the establishment of environmental radiological monitoring programs around dismantled or restored facilities, NORM facilities, and existing exposure situations where there is presence of radiological contamination caused by past activities or accidents; • In the period 2022 – 2030, some decision-making is to be done regarding responsibilities, scope and duration of the ongoing environmental monitoring programs carried out around former uranium mines or mills that have been already restored and, in some cases, closured; • Currently, Spain is considering to include the analysis of C-14 in vegetable and milk samples within the radioactivity monitoring programs around nuclear facilities. This is foreseen to be implemented in the next years; • In Spain, there are plans to close all nuclear plants by 2035. Therefore, in the next decade some NPPs will move on from an operation stage to a dismantling stage, requiring the adaptation of their radiological environmental monitoring programs to the new situation; • Fr the period 2022-2030, the CSN will continue to develop activities and criteria in order to promote the obtaining of the ISO 17025 accreditation by the national network of laboratories. Such as procedures, intercomparison exercises, R&D projects, etc... • The CSN's application that gives public access to the radiological environmental monitoring data within our database, KEEPER, is constantly updated. In the period 2022-2030 improvements in this application are expected.
Sweden	• There will be new regulations in place from 2022. It will thereafter be the license holders that design their monitoring program around their nuclear facilities, with the regulator reviewing and approving these local programs. SSM has started to investigate if and how an independent monitoring program could be set up and run by SSM in order to complement these programs run by the license holders; • There will be an increased use of GIS at SSM the coming years which will benefit both internal data analysis, external data sharing and information to the public (new map services for example, including realt time access to gamma stations); • Regarding emergency preparedness, there will be renewal of technical equipment. The national and local gamma stations are planned to be renewed and harmonized, new mobile dose rate instruments are planned for the organizations contracted for emergency measurements as described in the report, new dose rate instruments will be distributed to municipalities and county administrative boards; • National strategies for measurements in nuclear and radiological emergencies are under development.

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