EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

DIRECTORATE D – Nuclear energy, safety and ITER
D.3 – Radiation protection and nuclear safety

Verification under the terms of Article 35 of the Euratom Treaty

Technical Report

BELGIUM
Brussels

Routine and emergency radioactivity monitoring arrangements
Monitoring of radioactivity in drinking water and foodstuffs

12 – 16 July 2021

Reference: BE 21-04

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35

OF THE EURATOM TREATY

FACILITIES	Routine and emergency radioactivity monitoring arrangements in Brussels Monitoring of radioactivity in drinking water and foodstuffs in Brussels
LOCATIONS	Brussels, Mol and Fleurus in Belgium
DATES	12 – 16 July 2021
REFERENCE	BE 21-04
TEAM MEMBERS	Mr V. Tanner (team leader) Ms E. Diaconu
REPORT DATE	22 March 2022
SIGNATURES	

V. Tanner E. Diaconu

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Abbreviations

AVN	Authorized Inspection Organization
BELAC	Belgian Accreditation Body
FANC	Federal Agency for Nuclear Control
CBRN	Chemical, Biological, Radiological, Nuclear
CRM	Certified Reference Material
EC	European Commission
EME	Emergency, Measurements and Medical building
EURDEP	EUropean Radiological Data Exchange Platform
IRE	National Institute of Radioelements
GIS	Geographical Information System
GLTOE	Surveillance of the Territory and Natural Radiation Unit
GM	Geiger-Müller
HPGe	High-purity Germanium
IAEA	International Atomic Energy Agency
IBA	Ion Beam Applications
OBT	Organically Bound Tritium
ONDRAF/NIRAS	National Organisation for Radioactive Waste and enriched Fissile Materials (NIRAS: Nationale Instelling voor Radioactief Afval en verrijkte Splijtstoffen / ONDRAF: Organisme National des Déchets Radioactifs et des matières Fissiles enrichies
OSPAR	Convention for Protection of the Marine Environment of the North-East Atlantic
LIMS	Laboratory Information Management System
LSC	Liquid Scintillation Counter
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear Power Plant
PANORAMA	Digital interface of the TELERAD monitoring network
RADD	EC Radioactive Discharge Database
REM	EC Radioactivity Environment Monitoring database
ROI	Region of interest
SCK CEN	Belgian Nuclear Research Centre
TLD	Thermoluminescent dosimeter

TECHNICAL REPORT

1 INTRODUCTION

Under Article 35 of the Euratom Treaty, all Member States must establish the facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with basic safety standards[1]. Article 35 also gives the European Commission the right of access to such facilities to verify their operation and efficiency. The radiation protection and nuclear safety unit of the European Commission's Directorate-General for Energy is responsible for undertaking these verifications. The Joint Research Centre Directorate-General provides technical support during the verification visits and in drawing up the reports.

The main purpose of the verifications under Article 35 of the Euratom Treaty is to provide an independent assessment of the efficiency and adequacy of monitoring facilities for:

- liquid and airborne discharges of radioactivity from a site into the environment;
- levels of environmental radioactivity at the site perimeter and in the marine, terrestrial and aquatic environment around the site, for all relevant pathways;
- levels of environmental radioactivity on the territory of the Member State.

Taking into account previous bilateral protocols, a Commission Communication[2] describing practical arrangements for Article 35 verification visits in Member States was published in the *Official Journal of the European Union* on 4 July 2006.

2 PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 PREAMBLE

The Commission notified Belgium of its decision to conduct an Article 35 verification in a letter addressed to the Belgium Permanent Representation to the European Union. The Belgian Federal Agency for Nuclear Control (FANC) is the authority on the protection of population and the environment against the dangers resulting from ionizing radiation. The FANC was designated to lead the preparations for the visit.

2.2 DOCUMENTS

To assist the verification team in its work, FANC supplied an information package in advance[3]. Additional documentation was provided during and after the verification visit. The information provided was used as a source during drawing up the descriptive sections of the current report.

2.3 PROGRAMME OF THE VISIT

The Commission and the FANC discussed and agreed on a programme of verification activities in line with the Commission Communication of 4 July 2006.

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[1] Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom (OJ L 13, 17.1.2014)

[2] Commission Communication *Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty — Practical arrangements for the conduct of verification visits in Member States* (OJ C 155, 4.7.2006)

[3] Replies to the preliminary information questionnaire addressed to the national competent authority, received on 24 November 2020.

The opening meeting included presentations on the Belgian automatic radiation monitoring system and other environmental radioactivity monitoring arrangements. The verification team pointed to the quality and comprehensiveness of all the presentations and documentation.

The team carried out the verifications in accordance with the programme in Annex 1.

Verifications were combined with verifications of radioactivity monitoring arrangements of radiologically contaminated water catchment areas (Molse-Nete river and riverbanks, verification BE 21-05, 12-16.07.2021).

The verification team met the following representatives of the national authorities and other parties involved:

Federal Agency for Nuclear Control (FANC)

- Frank HARDEMAN, General Director
- Olivier ZEMB, Department Director GLDEP « Santé et Environnement » (Health and Environment)
- Geert BIERMANS, Head of Section GLTOE « Surveillance du Territoire et Rayonnement Naturel » (Surveillance of the Territory and Natural Radiation)
- Jurgen CLAES, Expert GLTOE « Radiological Surveillance of the Territory »
- Sylvain NOOTENS, Expert GLTOE « Radiological Surveillance of the Territory »
- François MENNESON, Expert GLTOE « TELERAD »
- Stéphane PEPIN, Expert GLTOE « Natural Radiation »
- Boris DEHANDSCHUTTER, Expert GLTOE « Natural Radiation »
- Sarah RADULOVIC, Expert GLTOE « Natural Radiation »

Belgian Nuclear Research Center (SCK CEN)

- Michel BRUGGEMAN, Head of Expert Group LRM
- Freddy VERREZEN, Technical Manager Radio-Analytical Laboratories (RAL): LRM
- Liesel SNEYERS, Technical Manager Sampling and Environmental Monitoring (SEM) and project leader Radiological Surveillance project at SCK CEN: LRM

Institute of Radioelements (IRE)

- Damien BRAEKERS, Responsible of the project of radiological surveillance of the territory and the Head of the Radioactivity Measurement Laboratory
- Olivia DERESTEAU, reporting and supervision

3 LEGAL FRAMEWORK FOR RADIOACTIVITY MONITORING IN BELGIUM

Belgium has a comprehensive legislation on monitoring radioactivity. The national legal provisions for environmental radioactivity monitoring, radiation surveillance of foodstuffs and international guidance documents are summarised in the sections below.

3.1 LEGISLATIVE ACTS REGULATING ENVIRONMENTAL RADIOACTIVITY MONITORING

In Belgium, the following legal texts regulate the monitoring of radioactivity in the environment:

- Law of 15 April 1994 on the Protection of the Population and the Environment against the Hazards of Ionizing Radiation and on the Federal Agency for Nuclear Control[4], articles 14, 15 and 21, Moniteur Belge 29 July 1994
- Royal Decree of July 20, 2001, modified by the RD 20/07/2020, laying down the general regulations for the protection of the population, workers and the environment against the danger of ionizing radiation, articles 70-71, Moniteur Belge 30 August 2001, edition 1 (GRR-2001)

The Royal Decree of 2001 (GRR-2001) provides the basic nuclear safety and radiation protection regulations amended and updated regularly in order to take into account scientific and technical developments and the European Union directives. Its Article 20 deals with limitation of doses and Articles 33 to 37 with radioactive waste and discharges.

In addition, there is an agreement with France from 8 September 1998, which lays down the principles of monitoring the environment around the Chooz NPP, located on the border between France and Belgium.

3.2 LEGISLATIVE ACTS REGULATING RADIOLOGICAL SURVEILLANCE OF FOOD AND DRINKING WATER

In Belgium, the following legal texts regulate the monitoring of radioactivity in food and drinking water:

- Law of 15 April 1994 on the Protection of the Population and the Environment against the Hazards of Ionizing Radiation and on the Federal Agency for Nuclear Control, articles 14, 15 and 21, ‘’Moniteur Belge’’ 29 July 1994
- Royal Decree of July 20, 2001, modified by the RD 20/07/2020, laying down the general regulations for the protection of the population, workers and the environment against the danger of ionizing radiation, articles 70-71, ‘’Moniteur Belge’’ 30 August 2001, edition 1.
- Loi du 4 février 2000 relative à la création de l’Agence Fédérale pour la Sécurité de la Chaîne Alimentaire, articles 4 and 5, Moniteur Belge, 18 February 2000
- Arrêté Royal du 22 février 2001 organisant les contrôles effectués par l’Agence fédérale pour la Sécurité´ de la Chaîne alimentaire et modifiant diverses dispositions légales
- Arrêté royal du 25 décembre 2016 portant sur l'échange et le croisement d'informations et de données entre l'Agence fédérale de Contrôle nucléaire et l'Agence fédérale pour la Sécurité de la Chaîne alimentaire
- Convention entre l’Agence Fédérale de Contrôle Nucléaire (FANC) et l’Agence Fédérale pour la Sécurité de la Chaine Alimentaire (AFSCA) of 6 April 2004, revised in 2012

[4] Modified by the Royal Decree (RD) of 7/08/1995, Law (L) of 12/12/1997, L 15/01/1999, L 03/05/1999, L 10/02/2000, RD 22/02/2001, RD 30/05/2002, L 31/01/2003, L 2/04/2003, L 22/12/2003, L 20/07/2005, L 27/03/2006, L 15/05/2007, L 22/12/2008, L 30/03/2011, L 1/07/2011, L 29/03/2012, L 21/12/2013, L 26/01/2014, L 19/03/2014, L 15/05/2014, L 7/04/2017, L 7/05/2017, L 13/12/2017, L 25/02/2018, L 19/04/2018, L 15/07/2018, L 6/12/2018, L 7/04/2019, L 13/04/2019, L 5/05/2019, L 22/04/2019.

3.3 LEGISLATIVE ACTS REGULATING RADIOACTIVITY MONITORING IN AN EMERGENCY SITUATION

In Belgium, the following legal texts regulate the monitoring in emergency situations:

- Royal Decree of March 1, 2018, laying down the general regulations for the nuclear and radiological emergency plan for the Belgian Territory
- Royal Decree of July 20, 2001, modified by the RD 20/07/2020, laying down the general regulations for the protection of the population, workers and the environment against the danger of ionizing radiation, article 72, Moniteur Belge 30 August 2001, edition 1 (GRR-2001)

3.4 INTERNATIONAL LEGISLATION AND GUIDANCE DOCUMENTS

The list below includes the Euratom and the European Union legislation and the main international standards and guidance that form the basis for environmental radioactivity monitoring and the radiological surveillance of foodstuffs and feeding stuffs.

The Euratom and the European Union legislation

- The Euratom Treaty
- Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom
- Council Directive 2013/51/Euratom of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption
- Council Decision 87/600/Euratom of 14 December 1987 on Community arrangements for the early exchange of information in the event of a radiological emergency
- Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety
- Council Regulation (Euratom) 2016/52 of 15 January 2016 laying down maximum permitted levels of radioactive contamination of food and feed following a nuclear accident or any other case of radiological emergency, and repealing Regulation (Euratom) No 3954/87 and Commission Regulations (Euratom) No 944/89 and (Euratom) No 770/90
- Council Regulation (EEC) No 2219/89 of 18 July 1989 on the special conditions for exporting foodstuffs and feedingstuffs following a nuclear accident or any other case of radiological emergency
- Council Regulation (EC) No 733/2008 of 15 July 2008 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station
- Council Regulation (EC) No 1048/2009 of 23 October 2009 amending Regulation (EC) No 733/2008 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station
- Commission Regulation (EC) No 1609/2000 of 24 July 2000 establishing a list of products excluded from the application of Council Regulation (EEC) No 737/90 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station
- Commission Regulation (EC) No 1635/2006 of 6 December 2006 laying down detailed rules for the application of Council Regulation (EEC) No 737/90 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station
- Commission Implementing Regulation (EU) 2016/6 of 5 January 2016 imposing special conditions governing the import of feed and food originating in or consigned from Japan

following the accident at the Fukushima nuclear power station and repealing Implementing Regulation (EU) No 322/2014
- Commission Recommendation 2000/473/Euratom of 8 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
- Recommendation 2004/2/Euratom of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation
- Commission Recommendation 2003/274/Euratom of 14 April 2003 on the protection and information of the public with regard to exposure resulting from the continued radioactive caesium contamination of certain wild food products as a consequence of the accident at the Chernobyl nuclear power station
- Council Directive 96/23/EC of 29 April 1996 on measures to monitor certain substances and residues thereof in live animals and animal products and repealing Directives 85/358/EEC and 86/469/EEC and Decisions 89/187/EEC and 91/664/EEC

International legislation and guidance documents, issued mainly by the International Atomic Energy Agency (IAEA)

- Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Brussels, 2014
- Clearance of materials resulting from the use of radionuclides in medicine, industry and research, IAEA-TECDOC-1000, IAEA, Brussels, 1998
- Generic models for use in assessing the impact of discharges of radioactive substances to the environment, Safety Reports Series No 19, IAEA, Brussels, 2001
- Handbook of parameter values for the prediction of radionuclide transfer in temperate environments, Technical Reports Series No 364, IAEA, Brussels, 1994
- Management of radioactive waste from the use of radionuclides in medicine, IAEA-TECDOC-1183, IAEA, Brussels, 2000
- Regulatory control of radioactive discharges to the environment: Safety Guide, Safety Standards Series No. WS-G-2.3, IAEA, Brussels, 2000
- Sources and effects of ionizing radiation, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000, Report to the General Assembly, Vol. I, United Nations, New York, 2000
- World Health Organisation (WHO), Guidelines on the quality of drinking water (Guidelines for drinking-water quality, 4th ed. 2011)
- OSPAR Convention for the protection of the marine environment of the North-East Atlantic
- International basic safety standards for protection against ionizing radiation and for the safety of radiation sources, General Safety Requirements Part 3, No. GSR Part 3, IAEA, Vienna, 2014
- IAEA Safety Standards, Environmental and Source Monitoring for Purposes of Radiation Protection, Safety Guide No. RS-G-1.8, 2005

4 BODIES HAVING COMPETENCE IN RADIOACTIVITY MONITORING

4.1 Federal Agency for Nuclear Control

The Federal Agency for Nuclear Control (FANC) is the authority on the protection of the population and the environment against the dangers resulting from ionizing radiation. It comprises five departments and employs some 160 members of staff. FANC was established by law of April 15th 1994. According to its position it has a great independency, necessary to take up the responsibility to the society in an impartial way. A board of directors leads the FANC, daily management being assured by a General-Director.

The law of 15 April 1994 attributes to FANC the objectives of protection of the population, workers and the environment against the dangers of ionising radiation, which consist of:

- propose, apply and improve law and regulations;
- control human (and non-human) activities responsible for exposure of man to radioactivity;
- ensure the surveillance of radioactivity on the territory (TELERAD automatic network and the radiological surveillance monitoring programme);
- co-operate in nuclear emergency planning;
- distribute neutral and objective information.

4.2 Bel V

Bel V is a subsidiary of FANC. It has taken over, since April 14th 2008, the regulatory controls in class I/IIA nuclear installations, formerly carried out by the Authorized Inspection Organization (AVN).

FANC relies on the technical expertise of the Bel V for carrying out inspections in nuclear power plants and other nuclear installations in Belgium (hospitals, universities and radionuclide production facilities). Bel V acts as an expert for the safety assessments of nuclear projects, participates in meetings and working groups that are organized in the framework of international organizations (EC, OECD, IAEA), exchanges information and experience feedback with Belgian and foreign colleagues, and contributes to the emergency plans for nuclear accidents.

4.3 National Crisis Centre

The National Crisis Organisation (NCCN) is the crisis response organisation of the Belgian government. The NCCN maintains stand-by services and analytical capabilities for national emergency situations, including nuclear and radiation emergencies.

5 RADIOACTIVITY MONITORING IN BELGIUM

5.1 INTRODUCTION

Belgium has a comprehensive programme for monitoring radioactivity in the environment. The programme comprises monitoring of radiation dose rate and radioactivity in atmosphere, soil, food, drinking water and surface waters. Monitoring of the Belgian territory, for both artificial and natural radioactivity, is performed:

- C*ontinuously* by the automatic TELERAD network, measuring in general local ambient radiation dose rate and in some specific stations also radionuclide concentrations;
- In an *intermittent* way via periodic sampling of environmental compartments.

Geographically, the radiological monitoring of the Belgian territory comprises two parts:

1. Monitoring of the territory outside the zones where significant nuclear activity is carried out. It indicates, in particular, the level of radioactivity to which the population is naturally subjected. It covers the zones far away from nuclear sites, such as the coastal region, as well as the so-called "reference" zones, such as the Brussels conurbation (largest urban area in Belgium with 10% of the population). Special attention is given to the surveillance of non-nuclear industrial sites and certain landfills.
2. Monitoring around nuclear sites where an activity liable to have a radiological impact on the environment is carried out. This essentially concerns the following sites:
   - Doel and Tihange NPPs
   - surroundings, on Belgian territory, of the French NPP at Chooz
   - Nuclear Research Centre (SCK CEN) at Mol
   - sites of Belgoprocess, Belgonucléaire (stopped in 2006, completely dismantled at the end of 2019) and Franco-Belge de Fabrication de Combustibles International (FBFC International, stopped in 2015, completely dismantled by end 2020) at Mol and Dessel
   - Joint Research Centre of the European Commission at Geel (JRC-Geel)
   - sites of the National Institute of Radioelements (IRE), Sterigenics and ONDRAF/NIRAS Fleurus site at the Fleurus industrial zone.

The monitoring around the installations and nuclear sites has several objectives:

- ensuring that the legal and regulatory provisions concerning environmental contamination remain respected;
- checking through the control of discharges into the environment that these comply with the standards and authorised limits;
- if necessary, assessing the potential doses received by particular sections of the population;
- informing the public in an objective manner.

Close monitoring also applies to installations where radionuclides are used, such as hospitals, universities or particular non-nuclear industries (NORM industry). Some landfills (mostly from phosphogypsum production) are also monitored.

5.2 AUTOMATIC RADIATION MONITORING NETWORK

5.2.1 General

Belgium has a modern automatic radiation monitoring network (TELERAD). The network has 260 stations covering the whole Belgian territory (Fig. 1). The network consists of:

- 160 Ambient gamma dose rate stations (IMN +IMA)
- 60 Air gamma spectrometry stations, located in ring around nuclear sites and in the nearby agglomeration of NPP'S sites (IMR)

- 12 Water gamma spectrometry stations, immersed directly in rivers or through by-pass in containers (IMW) and/or immersed in release channels of NPP's (EMW)
- 7 Aerosol alpha/beta/^{131}I collector stations (AER/IOD)
- 23 Mobile air gamma dose rate stations (MOB/D)

The TELERAD network is a measuring and early warning network, which has the following two major objectives:

- Continuous recording of measurements to provide all necessary statistical information on the level of radiation found in the country;
- Setting off, without delay, of an alarm to signal the exceeding of a warning threshold.

TELERAD is thus an alarm network that enables real-time detection of any abnormal situation, which may lead to the launching of the Emergency Plan for Nuclear Risks.

In the event of a nuclear accident, TELERAD will play an important role in the taking of decisions, optimising interventions and countermeasures implemented by the relevant authorities, as well as keeping the country's citizens informed on an ongoing basis.

The measurement frequency in air and water is 10 minutes; the system generates an automatic alert to FANC, when a predetermined value or threshold is exceeded.

Data from the TELERAD system is collected by the PANORAMA software, which is installed at the FANC (Brussels) and the IRE (Fleurus). There is a team of experts in charge of TELERAD operation and maintenance at FANC, which performs a 24/7 guard duty.

The stations are distributed throughout the entire country for nationwide monitoring and on rings around the nuclear sites (Tihange, Doel, Mol-Dessel, Fleurus and Chooz), and on the urban areas close to the nuclear installations (~5 km). In addition, in ad-hoc selected sewage purification plants water radioactivity is monitored in situ with automatic (submerged) gamma spectrometry probes.

5.2.2 Network development

The network was modernised in 2010. The modernisation comprised replacement of all stations with new generation stations with modern data communication links. To improve the nuclear sites surveillance, the ring stations (situated around the sites on the fence) have been equipped with gamma spectrometry detectors to assure quick identification of nuclides present in the ambient air.

In addition, the existing river stations have been modified and are now equipped with gamma spectrometry detectors for identification of nuclides. New automatic gamma spectrometry probes are implemented upstream and downstream of the Doel NPP on the Scheldt river. The surveillance of the aquatic releases from NPPs is now directly done by automatic gamma spectrometry probes placed at the outlet of the release channels of the NPPs (Tihange and Doel).

In 2019, an optimisation was carried out: 50% of the spectrometry stations located around the fence of the nuclear power plants were moved to the urban areas. The ambient dose rate stations, which were replaced by these spectrometry detectors in these urban areas, made the other way. This gives the advantage of having online spectrometric information on atmospheric releases in a larger area.

Since 2019, the TELERAD network exchanges directly the gamma dose rate values with France, Germany and the Netherlands. The interface of surveillance (PANORAMA) contains all measuring stations located within 50 km from the Belgian border.

All stations are linked to a centralised system that is automatically alerted when detecting any abnormal rise in radioactivity levels or when a nuclide activity is detected above a pre-set threshold on the ring stations. The central system has a full redundant set-up at a disaster recovery site.

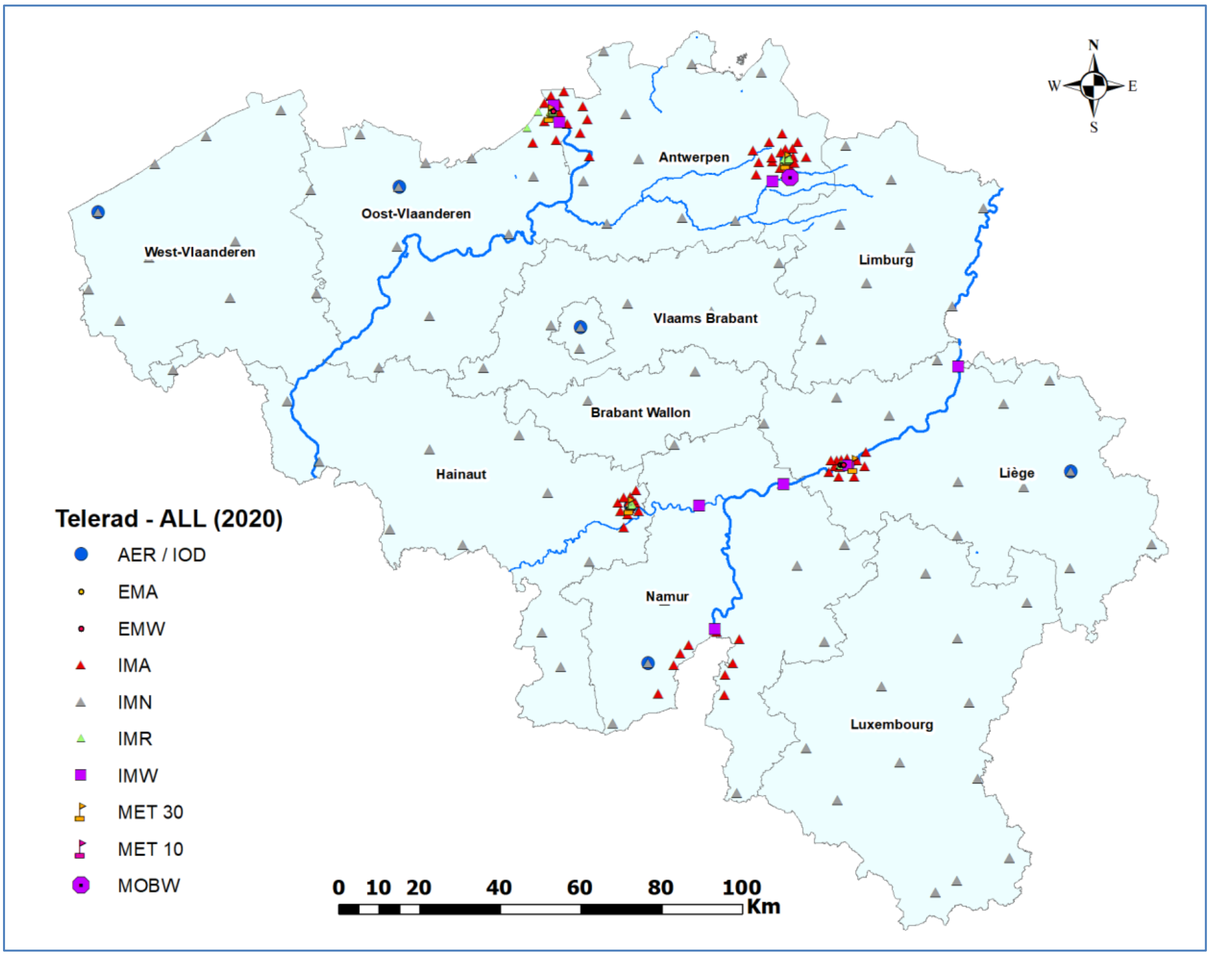

Figure 1. ***Nationwide TELERAD network of radiation monitoring stations***

5.2.3 Gamma dose rate stations

The TELERAD gamma dose rate network comprises 160 GM gamma dose rate detectors (IMN) placed on the entire country (Figures 2 and 3). The IMN stations are generally placed at max 20 km from one to another. The IMA stations are place around the nuclear sites. The stations have been supplied by the German company ENVINET GmbH.

The stations are used for measuring the ambient gamma radiation dose rate. In addition, there is detection of precipitation (yes/no)[5]. In total, there are 162 on the Belgian territory (including those around the boot of Givet for monitoring the Chooz nuclear site). A first level alarm is given at background level + 70 nSv/h and second at background level + 270 nSv/h.

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[5] For each measuring station, FANC receives precipitation data in ml/m² from the Royal Belgium Meteorological Institute, calculated from their meteorological models.

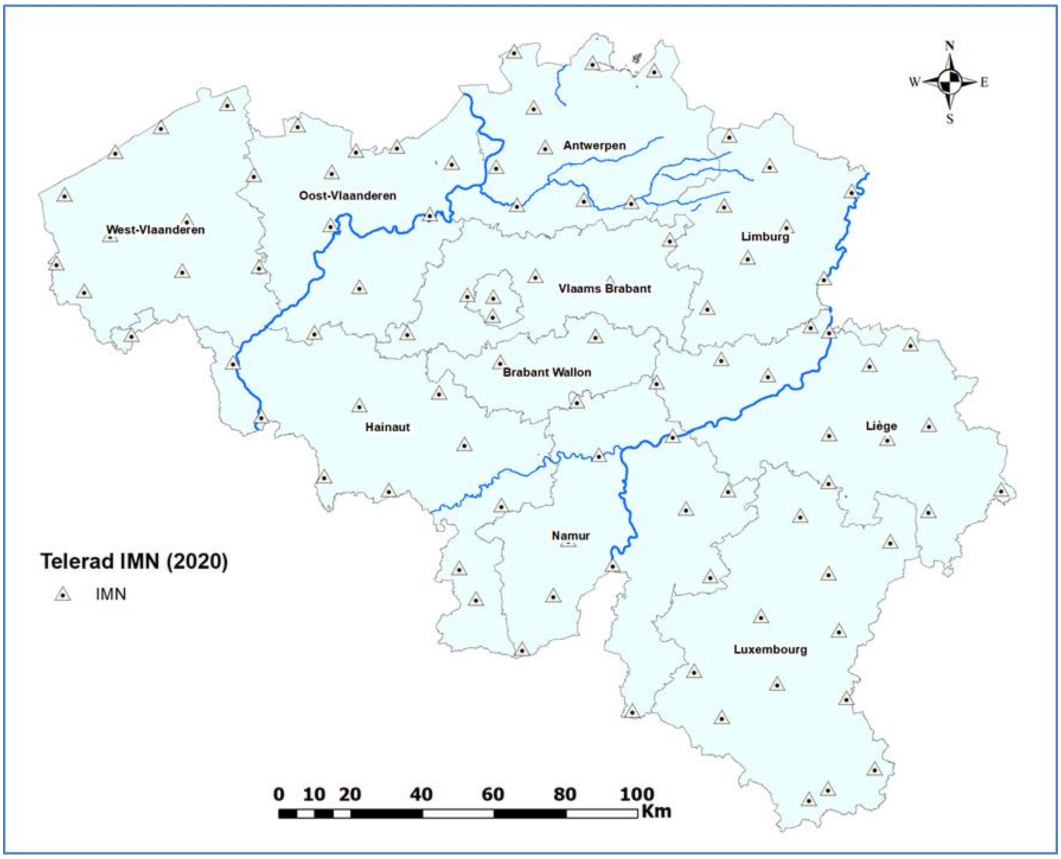

Figure 2. Distribution of IMN stations

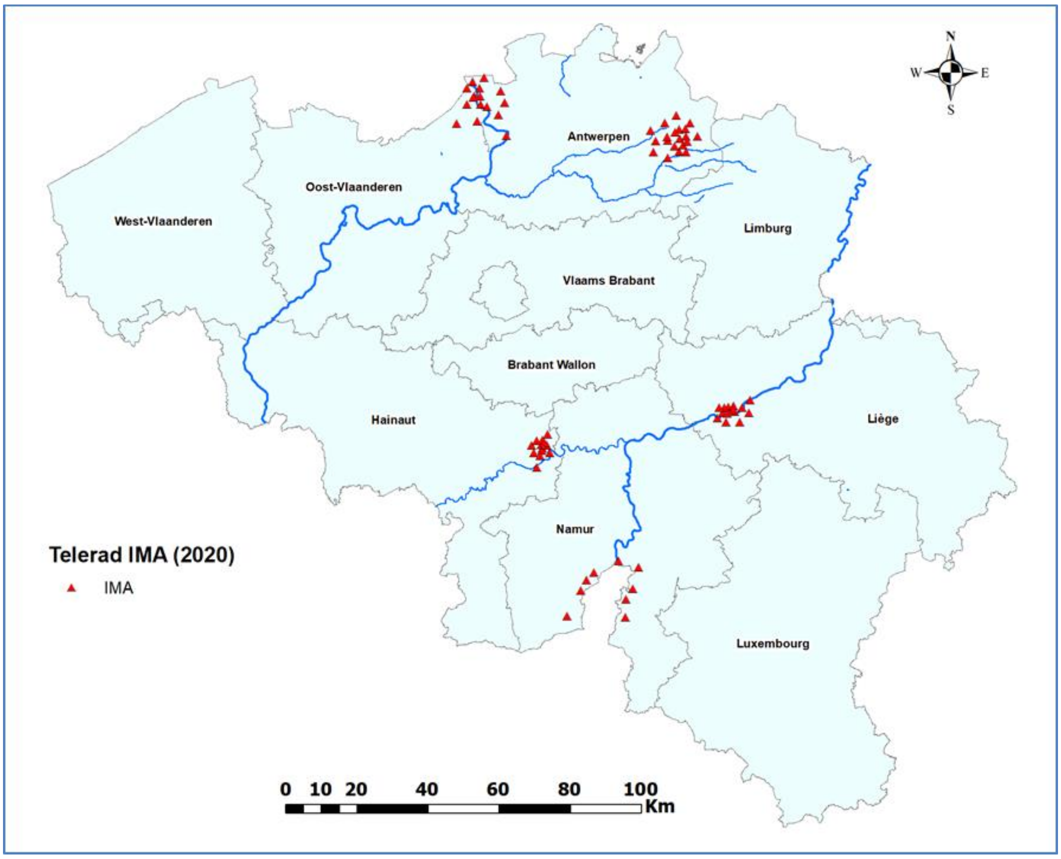

Figure 3. Distribution of IMA stations

A gamma dose rate station has one low dose rate GM detector and one high dose rate GM detector. The station stainless steel box is waterproof and has a protection for solar radiation allowing good functioning of the station without ventilation and in hard weather conditions (Fig. 4, 5 and 6).

Low Dose Detector Specifications (GM Detector Type 70031A):

- Sensitivity: 10 nSv/h...2 mSv/h
- Efficiency: 823 cpm/µSv/h
- Detector noise floor: 38 cpm*
- Count rate at overload point: 300,000 cpm, value automatically subtracted from the measured value

Specifications of High Dose Detector (GM Detector Type 70018A):

- Sensitivity: 100 µSv/h...10 Sv/h
- Efficiency: 1.03 cpm/µSv/h
- Detector background noise: n.a.
- Count rate at overload point: 3,000,000 cpm

Figure 4. TELERAD gamma dose rate station

Figure 5. Station electronics

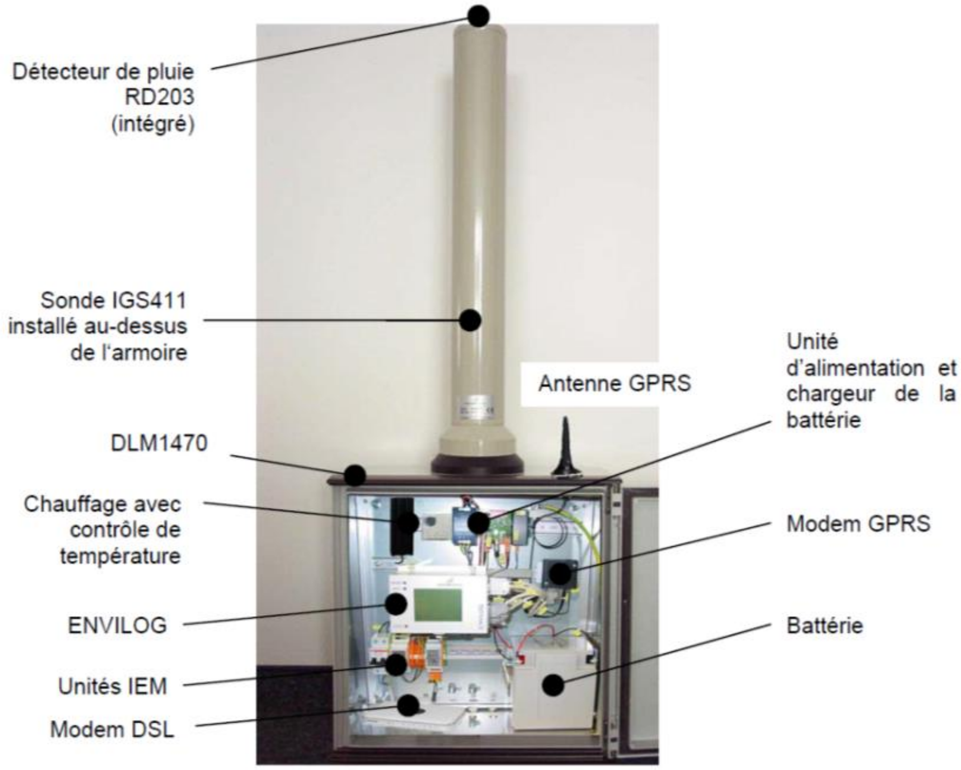

Figure 3-1: Composantes principales de la station de mesure de dose gamma

Figure 6. TELERAD gamma dose rate station components

5.2.4 Spectroscopic stations

Part of the TELERAD network are the IMR stations, which have an Envinet SARA spectrometer detector. These 72 gamma spectrometry stations have a NaI detector for measuring the total ambient gamma radiation dose rate and the gamma radioactivity of 10 predefined radionuclides. The stations are distributed on the fences around all nuclear sites (SCK CEN, Belgoprocess, nuclear power stations of Tihange and Doel and the IRE) and in the agglomeration (~5 km around the site) of the Doel/Tihange NPP (Fig. 7).

Technical specifications of the spectrometric stations:

- Sensitivity of the detector: 10nSv/h – 10 Sv/h
- Library contains almost 100 radionuclides
- Automatic nuclide analysis on 10 predefined radionuclides
- Calculated nuclide dose rate based on the spectrum
- 3 days autonomy of the battery in case of power loss
- Memory for more than one month of data storage

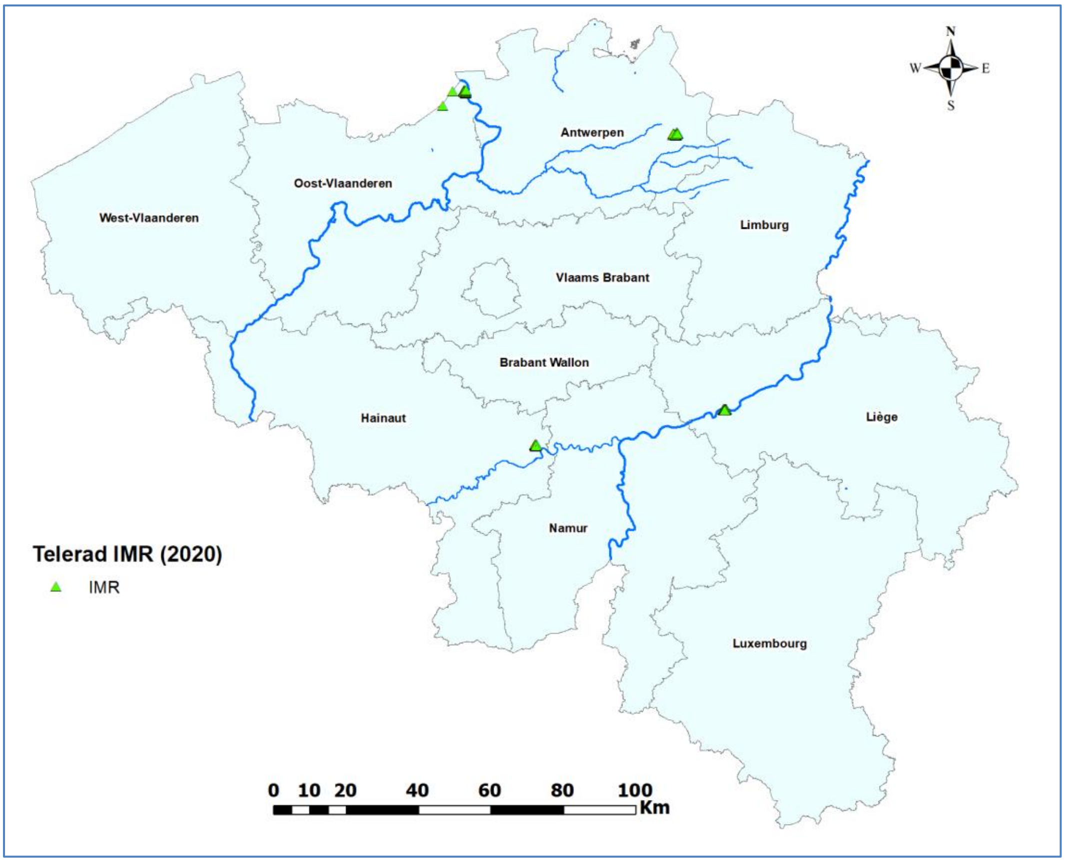

Figure 7. Locations of IMR spectroscopic monitoring stations

Three spectrometric stations have been installed around the Belgoprocess site in 2018 (Fig. 8). These stations have the particularity of being powered by solar panels and can be moved by means of a trailer.

Figure 8. Solar powered spectroscopic monitoring station at the Belgoprocess site

5.2.5 Water monitoring stations

Automatic monitoring of river water radioactivity is performed by 12 TELERAD river stations (IMW), which continuously measure the gamma radioactivity of river waters. Two types of stations are used: IMW Retrofit (6) and IMW BCI (6) stations. Figure 10 shows their locations.

IMW Retrofit stations are installed close to the three rivers receiving discharges from nuclear sites and waste water from major urban centres (combining research centres, universities and hospitals): on the Meuse river, on the Sambre river and on the Nete river. These stations are large containers, from which inlet and outlet pipes allow river water to be pumped to the detector and returned after radioactivity has been measured (Figure 9).

Two IMW BCI stations, directly immersed in the river water, are installed in the Scheldt downstream and upstream of the Doel nuclear power plant. Four other IMW BCI stations, located in the release channels of the nuclear power plants, continuously measure the gamma radioactivity of the liquid discharges: one in the release channel of the Doel nuclear power plant and three in the release channels of the Tihange nuclear power plant.

The BCI stations can also be used as mobile (immersed) probes. FANC has four of these additional MOB/W stations.

Figure 9. TELERAD IMW automatic river water monitoring station

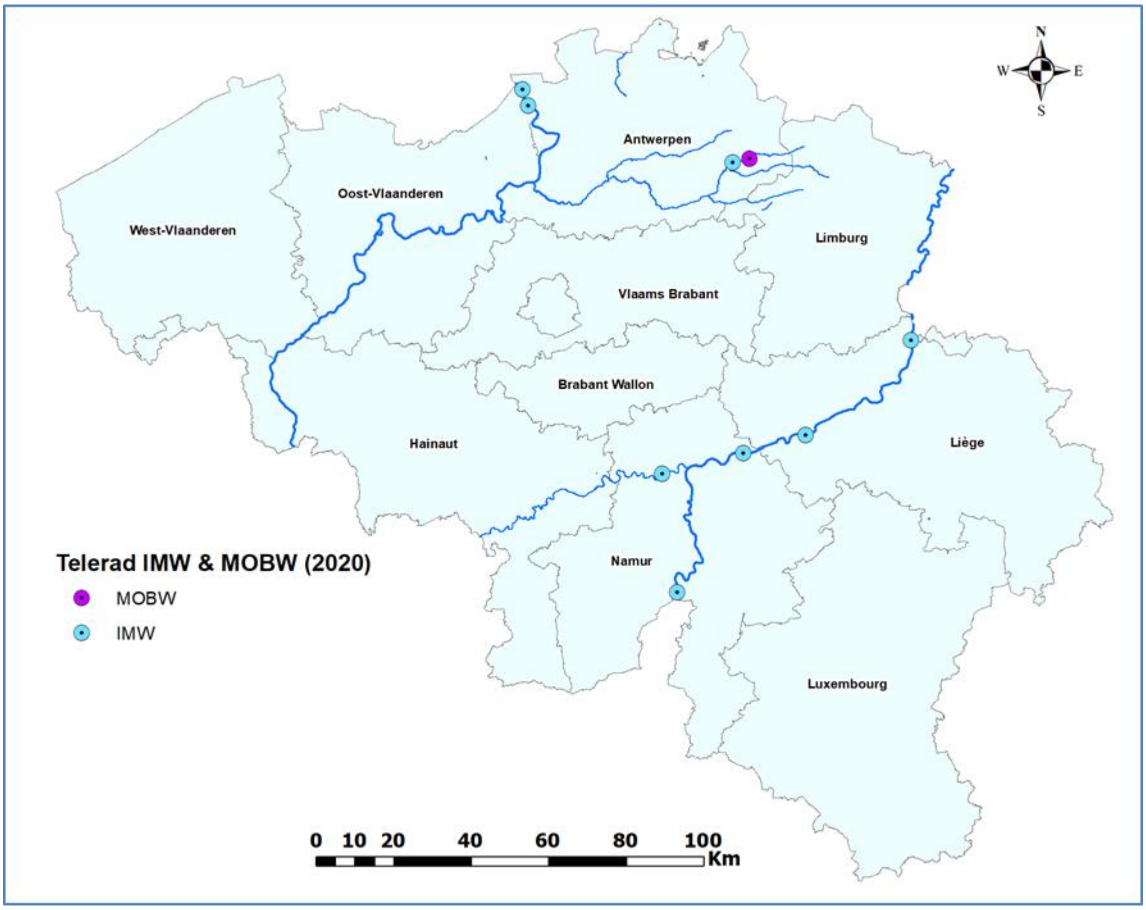

Figure 10. TELERAD river water monitoring station locations

5.2.6 Air monitoring stations

There are 7 automatic air monitoring stations (AER/IOD) with a ZnS detector in Belgium, distributed as shown in Figure 11, for measuring the radioactivity of dust suspended in the air (aerosols and fine particles). The stations measure the total alpha and total beta radioactivity in air. When a certain total beta threshold is exceeded (level alpha = 3 Bq/m³; level beta = 3 Bq/m³), air is pumped through an active charcoal filter (IOD) for trapping possible radioactive iodine. If the warning thresholds are exceeded, active carbon cartridges intended to trap the radioactive iodine, are automatically measured after pumping the outside air in order to determine the level of radioactivity.

These stations have been supplied by BAI-Berthold company (types BAI 9850-7 and BAI 9850-23). The systems include diesel generators for electrical back up.

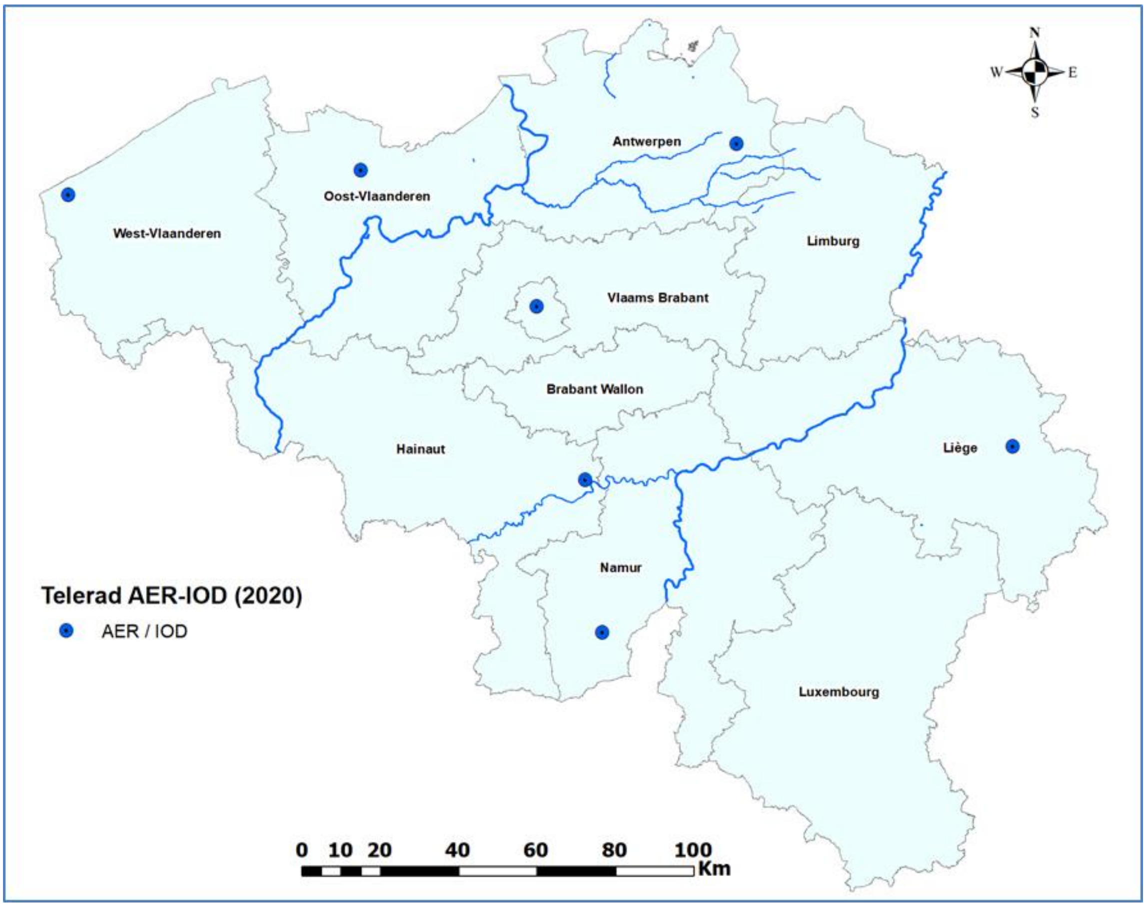

Figure 11. Automatic air monitoring stations

Figure 12 below shows the alpha/beta measuring unit with a view of the unreeling filter tape, which collects the dusts and particles when the air is pumped (left side view). The right side view shows the detector in its casing (cylinder) and the parallel-piped tube containing the active charcoal cartridges.

Figure 12. TELERAD automatic air radioactivity monitoring station (AER/IOD)

5.2.7 Software and communications

The display interface for all TELERAD stations is made using the PANORAMA software, which allows instantaneous display (using a color code) of the status of the measurement stations. The system provides also data from stations placed 50 km beyond the Belgian border, thanks to data exchange collaboration with the neighboring countries (except Luxembourg). A Geographical Information System (GIS) has been installed to allow use of several layers (Precipitation layer, Ring station layer, Mobile station layer…). Gamma dose rate mobile stations' locations are refreshed each 2 hours (unless an alarm threshold has been exceeded, than the refresh rate will be 10 min) (Fig. 13).

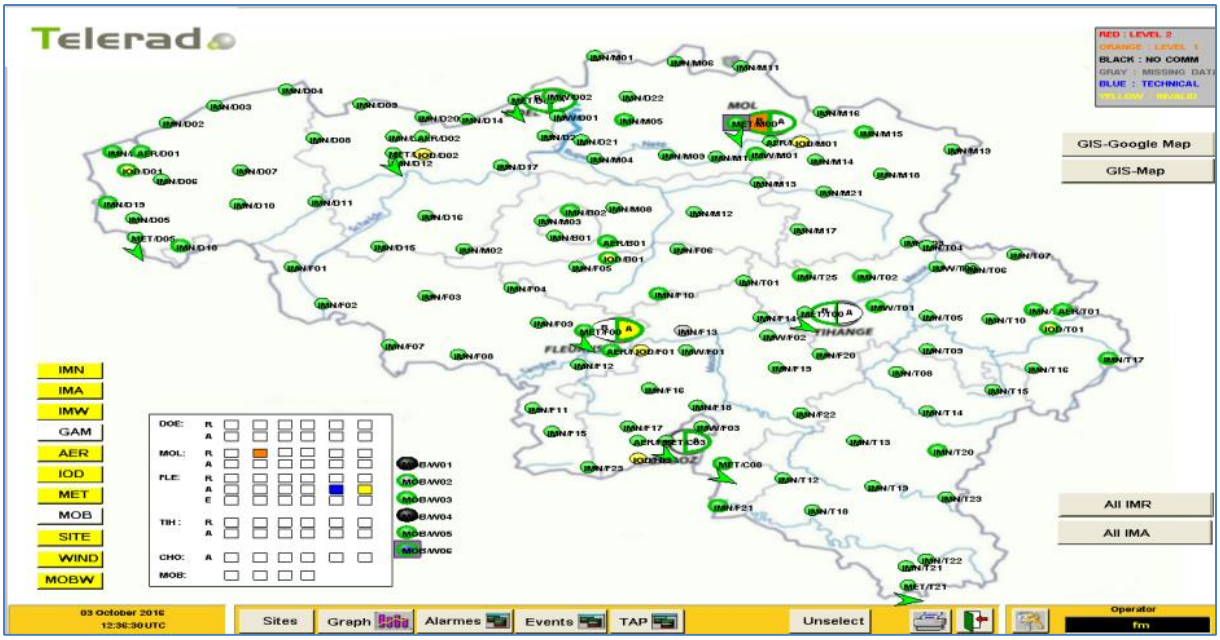

Figure 13. TELERAD system display (PANORAMA software)

TELERAD network uses two means of communication:

- ADSL connection via Ethernet provided by WIN S.A.
- Blue Light Mobile network supported by a public entity called Astrid S.A. This network is only used by authorities, such as firefighters, police and civil protection. The network allows FANC to have priority on "standard" communication. This new way of communication was implemented in 2018.

5.3 ENVIRONMENTAL SAMPLING

5.3.1 Air and atmospheric deposition

Monitoring of radioactivity in air and atmospheric deposition is performed by sampling air dust and surface deposits. The samples are analysed at the IRE and SCK CEN laboratories.

Monitoring in the vicinity of the nuclear sites and in the reference zones Brussels Capital, Coxyde (at the Nord Sea coast) and Lixhe at the Meuse (nearby the border of the Netherlands) is done using air dust samplers (Outdoor Aerosol Sampling Intelligent System) (Fig. 14).

The surface deposits (dry deposits of particles and/or wet deposit from rain) are collected in tank collectors with known surface area containing a thin layer of water to trap the fine particles.

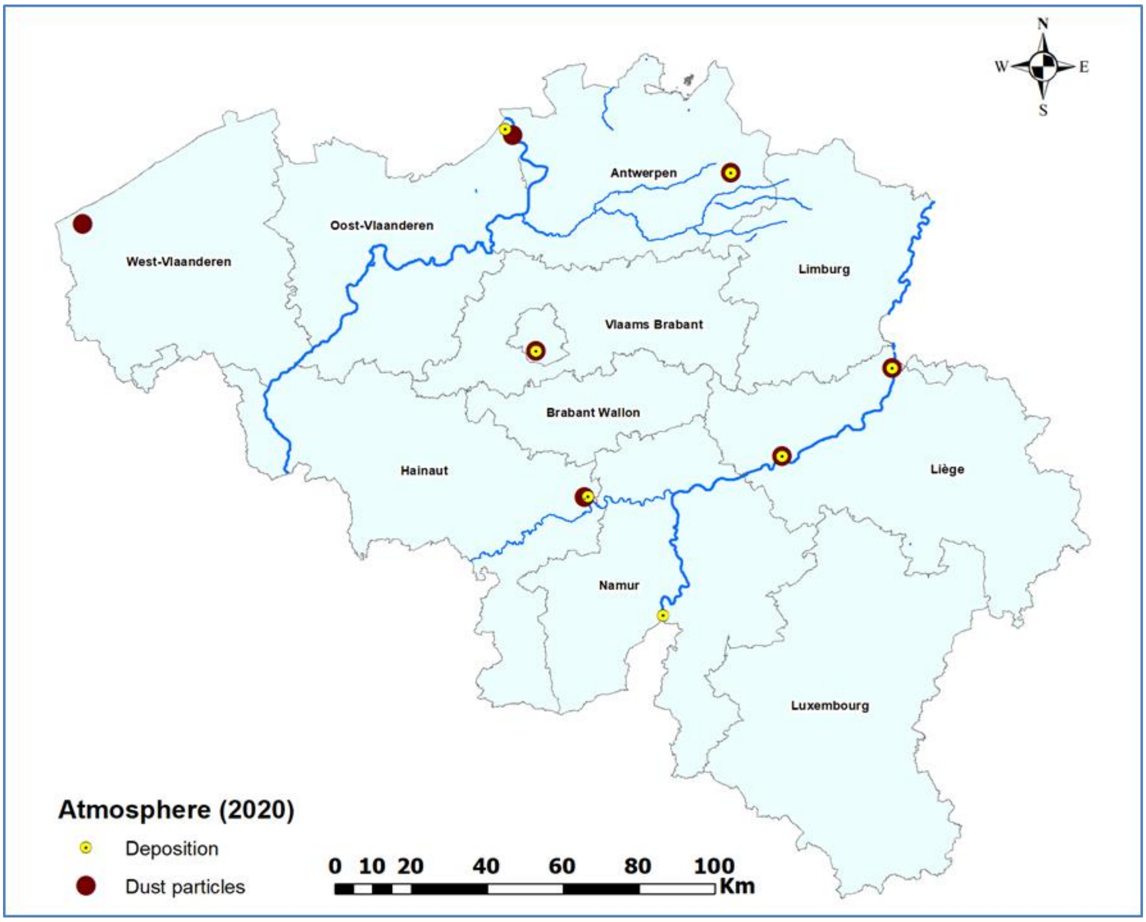

Figure 14. Locations of the large-volume air filter and deposition collector stations

Airborne dust samples are collected daily using two types of sampling systems:

- In Brussels, Fleurus, Tihange and Lixhe airborne dust is collected using an automatic sampling system with a daily sample changer, pumping about 120 m³/h of air, at constant flow rate, from 00:00 to 24:00 for the seven days of the week (Figure 15). Once a week, the seven filters (fibreglass filter of 50 mm diameter) are replaced by new ones. The pumping volume through each filter is downloaded automatically.
- In Mol and Doel daily samples and in Coxyde 2-daily samples are collected using a specially designed installation consisting of a filter holder, a paper (cellulose) filter with a diameter of 115 mm and an air pump, which continuously pumps air through the filter paper (Figure 16). Total volume of the air pumped through the filter is measured by an integrating flow meter (approximately 300 m^3 in 24 hours). The filter paper is replaced every 24 hours. Collection date, time and the total volume of air pumped through the filter are registered.

Filter samples are kept for minimum of 5 days to allow the decay of the short-lived natural radionuclides. After 5 days decay time a beta global measurement is done for each filter and an alpha global measurement is done for the filter collected in Mol. After alpha and/or beta global measurements all filters are stacked, placed into a plastic bag/container to make a 4-week composite sample, and then sent to the lab for measurement of gamma emitters by gamma spectrometry.

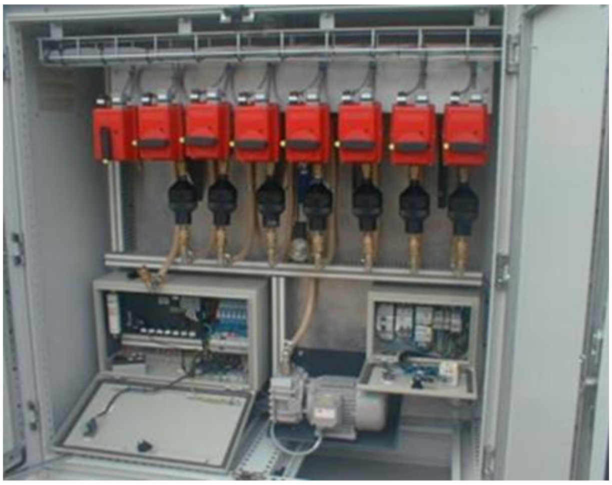

Figure 15. Air sampler with a filter for each day of the week

Figure 16. Air sampler with a single filter

5.3.2 Surface water

Off-line monitoring of surface waters is part of the general surveillance programme. Samples are collected every week or every second week (depending on the storage capacity) from the rivers Sambre, Meuse, Molse Nete and Scheldt. For marine waters, samples are collected from specific locations in the North Sea.

Automatic samplers are used (Fig. 17), in general installed in the containers of the TELERAD river stations (Fig. 10). These enable water to be pumped into flasks for gamma, alpha and beta spectrometry. This fully programmable unit enables pre-determined volumes of water to be collected over a fixed time period and frequency.

Each sample is acidified by concentrated Nitric Acid to pH < 2. Samples are stored for 24 hours in a cool dark place (between 1 and 5°C) before further processing. A mixed sample is prepared by mixing 14 consecutives daily samples together. The mixed sample is filtered and the filter is discarded. The mixed sample is divided into subsamples, according to the requested analyses. The rest of the samples are stored in the original bottles in a cool and dark storage room (between 1 and 5°C).

Figure 17. Automatic river water sampler (Buhler)

5.3.3 Ground water and drinking water

Drinking water samples are collected from the distribution networks (tap water) at points spread evenly throughout Belgium (Fig. 18 and Table I).

As part of its diverse activities outside of the radiological surveillance programme, FANC regularly gathers data on natural radioactivity in groundwater from the different aquifers (and water bodies) present in Belgium. These analyses, though not individually aimed at evaluating the global radiological state of an aquifer, allow on long term the establishment of average radioactivity levels for groundwater from the different aquifers. In addition, FANC works together with the Brussels-Environment in Brussels in order to perform radioactivity analysis on selected samples of their control network of quality of groundwater.

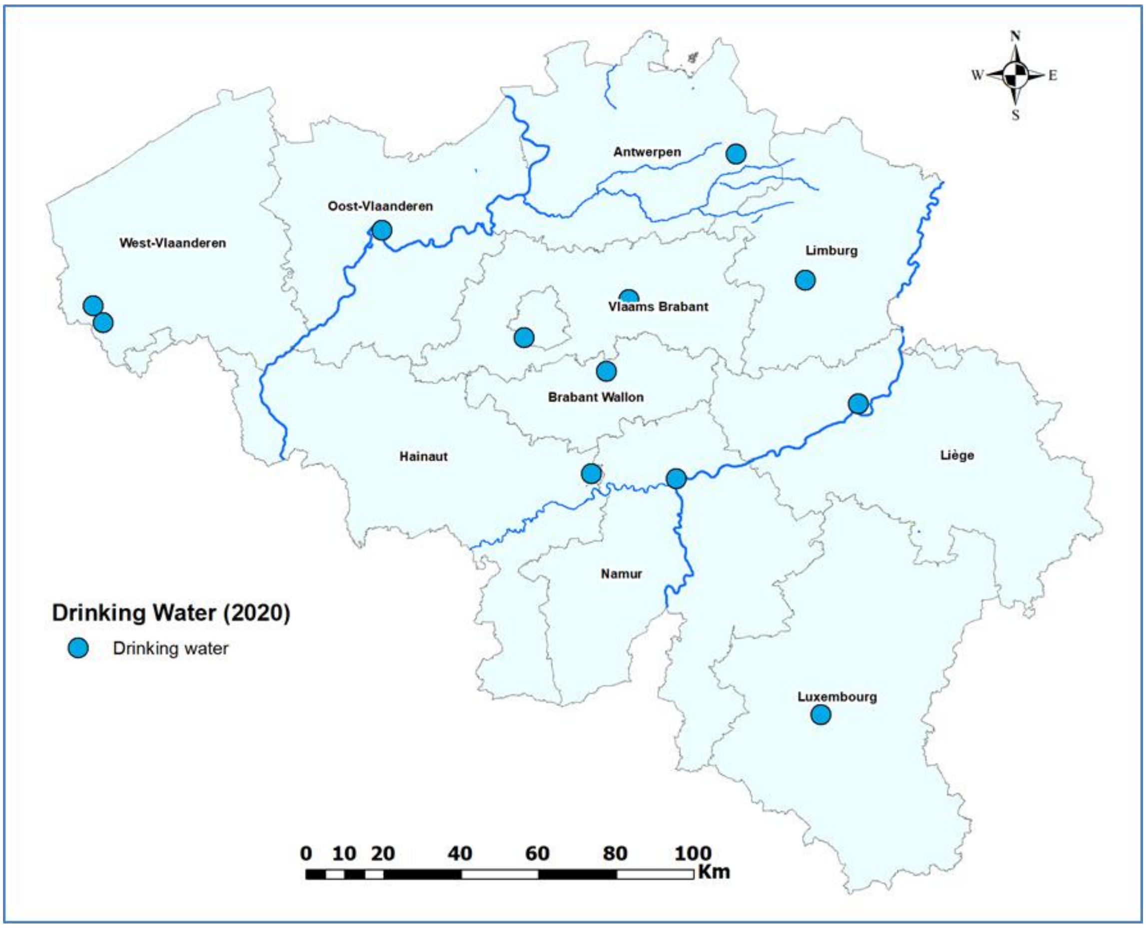

Figure 18. Sampling locations for drinking water in Belgium

Table I. Radiological monitoring programme for drinking water

Zone		Location of sampling points	Type of measurement	Frequency of sampling
Drinking water	mains (tap)	Brussels (Brussels Capital) Wavre (Walloon Brabant) Liege (Liege) Namur (Namur) Fleurus (Hainaut) Florenville (Luxembourg) Ghent (East Flanders) Leuven (Flemish Brabant) Poperinge and Reningelst (West Flanders) Mol (Antwerp) Hasselt (Limburg)	Spectrometry total α & total β (β residual), ^{3}H, ^{40}K, ^{222}Rn, ^{226}Ra Where screening values are exceeded by 0.1 Bq/L in total alpha and 0.2 Bq/L in beta residual (1 Bq/L total beta), complete spectrometry analyses (γ, α, β)	Quarterly

5.3.4 Soil

Samples of soil are collected annually in the immediate vicinity of nuclear sites and certain control regions (sea coast, Brussels Capital region) (Fig. 19). A total surface of 0.125 m² to a depth of 0.15 m is collected for each sample.

Locations near nuclear facilities (e.g. Doel, Mol, Fleurus, Tihange) are situated downwind from the facility (prevailing wind direction) in an open space, and if possible with a flat surface. Any vegetation (such as grass) is removed by cutting as close to the surface as possible and discarded. Once the surface is cleared, the soil is removed up to a depth of 15 cm and collected in an appropriate container.

The sample is dried at 40°C for 24 hours. Stones, roots, etc. are removed by sieving the sample over a 2 mm mesh sieve (material remaining on the sieve is discarded). The remaining sample is dried at 40°C until constant weight and then grinded to homogeneity. From the homogenized sample, a beaker is filled for gamma spectrometry measurement. For the ^{226}Ra activity determination, measurement is performed on its gamma emitting daughter nuclides (^{214}Bi and ^{214}Pb) after an ingrowth period of minimum 2 weeks. The sample is sieved over a 200 µm sieve for alpha spectrometry and ^{90}Sr analysis. From the homogenized sample, an appropriate amount is taken for calcination at maximum 550°C. This sample is sent to the lab for measurement of actinides by alpha spectroscopy and for ^{90}Sr analysis, based on a complete digestion of the sample. The residual dried soil sample is kept in a dry place.

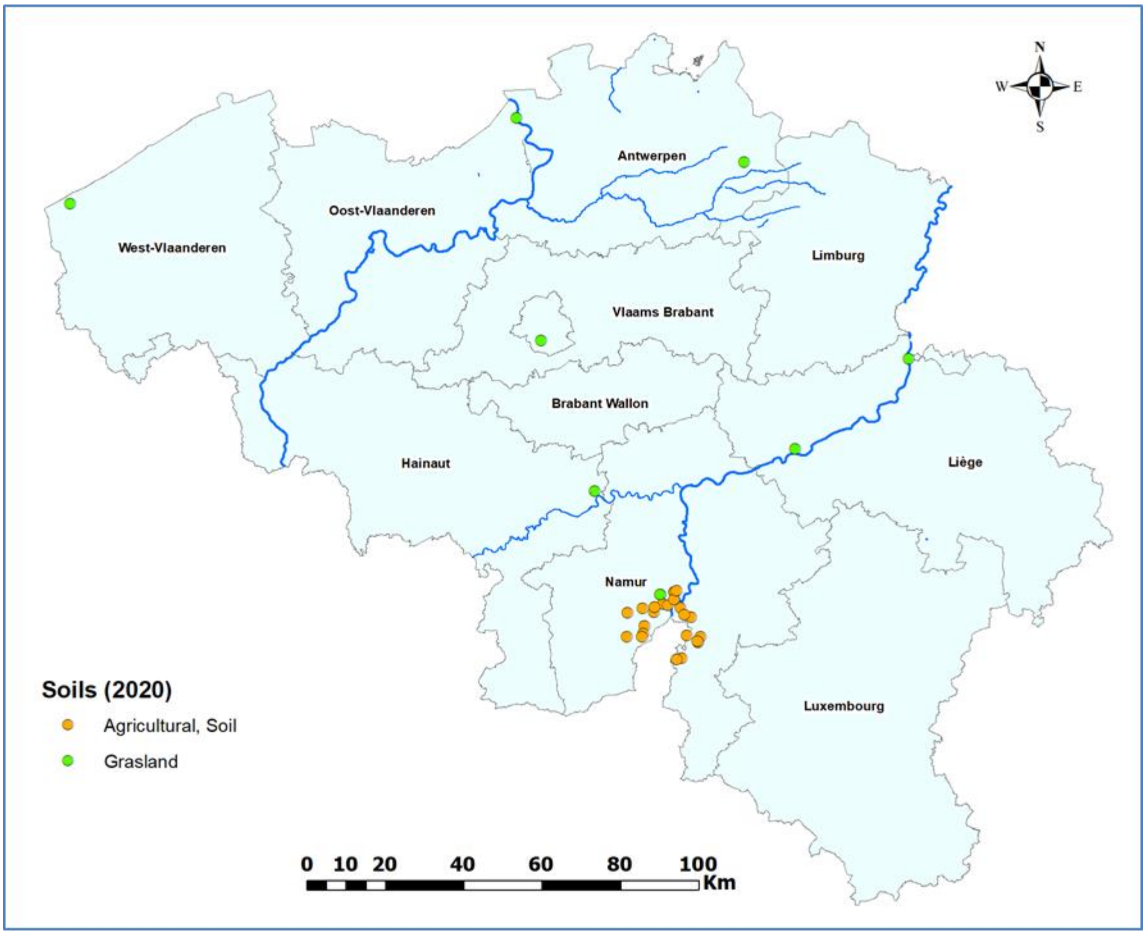

Figure 19. Soil sampling locations

5.3.5 Sediments

Monitoring of sediments includes sea sediments (North Sea) and river sediments (Sambre, Meuse, Molse Nete, Scheldt) (Fig. 20). Samples are collected in plastic containers and stored in a cool dark place.

For the sampling of river sediments, three different systems are used:

- Automatic sampler installed in TELERAD cabins (Molse Nete, Sambre and Meuse). The sediment sample is collected every 4 weeks and transferred into a recipient.
- Sedimentation bin. At the beginning of the sampling period, a sedimentation bin is placed in the river stream on the bottom, attached to a fixed point on the river bank. After 4 weeks, the bin is retrieved and all collected sediment is transferred into a recipient.
- In Doel, the upper layer of the sediment is scraped of every 4 weeks during low tide with a shovel.

The collected sediment sample (river or sea) is dried at 40°C to constant weight in an oven or freeze dried. Stones or other larger debris are manually removed. The total sample is then grinded to 2 mm. From the homogenized sample, depending of the sediment amount, a beaker is filled for gamma spectrometry measurement. For the ^{226}Ra activity determination, measurement is performed on its gamma emitting daughter nuclides (^{214}Bi and ^{214}Pb) after an ingrowth period of minimum 2 weeks. Using a sample splitter, a subsample taken and is grinded to pass a 200 µm sieve for alpha spectrometry, ^{99}Tc and ^{90}Sr analysis.

From the homogenized sample, an appropriate amount is used for calcination at 550 °C. This sample is sent to the lab for measurement of actinides by alpha spectroscopy and for the measurement of ^{90}Sr and ^{99}Tc if required. The residual dried soil sample is kept in a dry place.

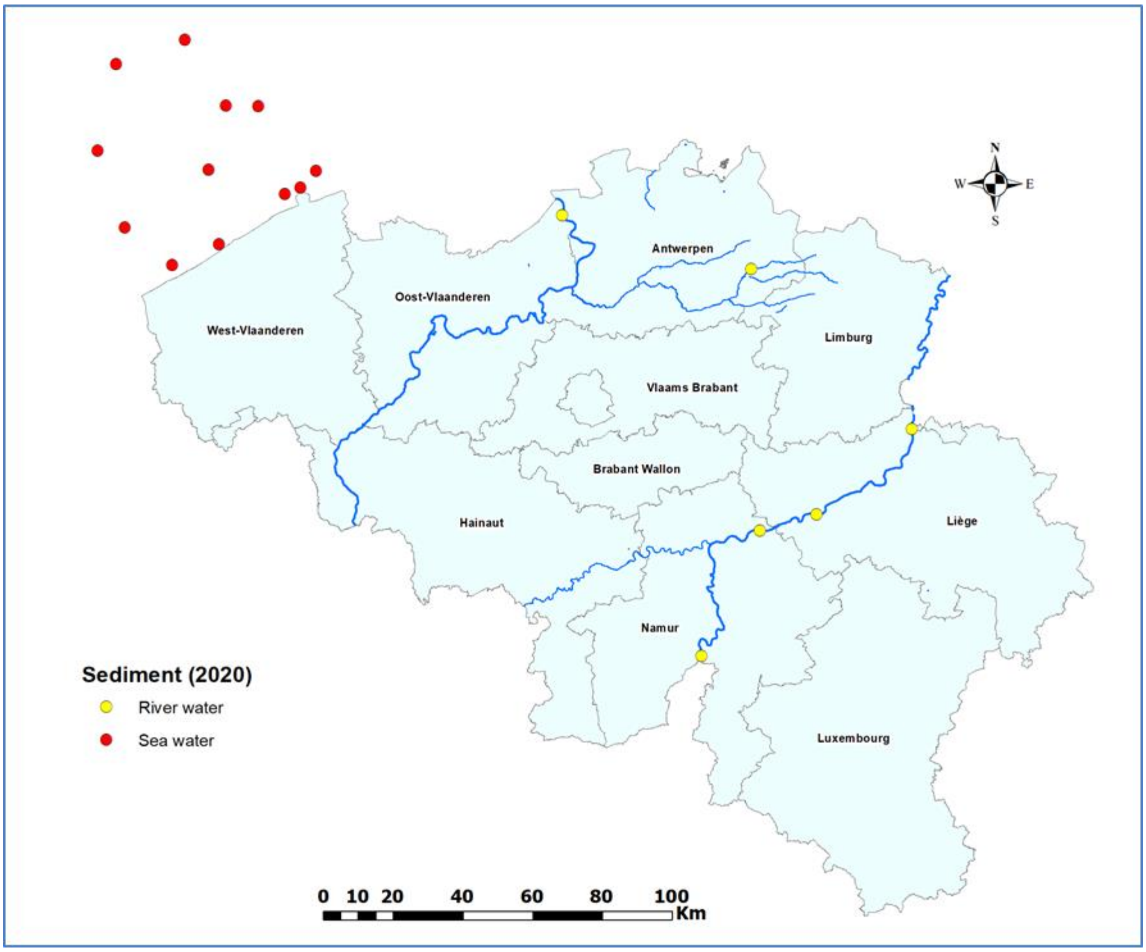

Figure 20. Sediment sampling locations

5.3.6 Terrestrial and aquatic biota and flora

Monitoring the living environment is carried out by measuring radioactivity in fauna in fresh and salt water (molluscs from fresh and salt water, shrimps and fishes) and in flora in fresh water (aquatic plants and mosses) and in seawater (algae) (Fig. 21).

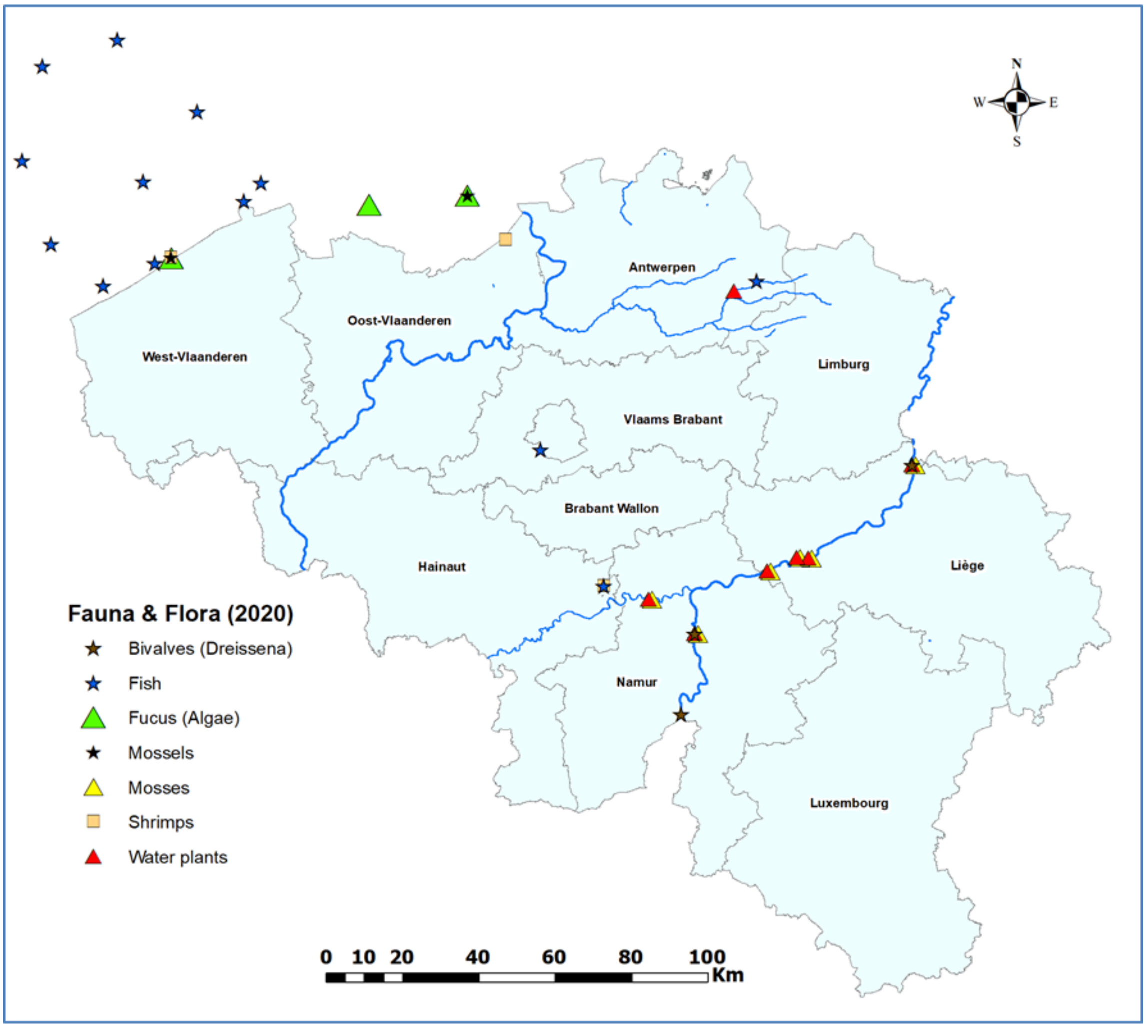

Figure 21. Sampling locations for flora and fauna

Aquatic flora samples are collected along riverbanks (Meuse & Sambre). The samples consist of tree leaves and branches, moss, alga, etc. Samples of mussels (Dressena) are recovered by using a special tool allowing to scrape up the banks a few meters deep. Samples are rinsed with tap water, cut into pieces, dried in an oven at 40°C until constant weight and grinded. Part of the sample is transferred into a container for measurement by gamma spectrometry. For the ^{226}Ra activity determination, measurement is performed on its gamma emitting daughter nuclides (^{214}Bi and ^{214}Pb) after an ingrowth period of minimum 2 weeks. Part of the sample is transferred to the liquid scintillation laboratory for measurement of organically bound tritium (OBT). Another part of the sample is treated in a microwave oven (total dissolution) and the resulting solution is transferred to the lab for measurement of ^{90}Sr and actinides (only for the Molse Nete). For measurements of ^{99}Tc, part of the dried sample is transferred to the laboratory, treated in a microwave oven (total dissolution) and the resulting solution is measured by liquid scintillation for ^{99}Tc content (only for the Molse Nete samples).

For river mussels from the Meuse and Sambre rivers the sample is rinsed with tap water and dried in an oven at 40°C for 3 days and grinded. Part of the sample is transferred into a plastic container for measurement by gamma spectrometry. For the ^{226}Ra activity determination, measurement is performed on its gamma emitting daughter nuclides (^{214}Bi and ^{214}Pb) after an ingrowth period of minimum 2 weeks. Part of the sample is transferred to the liquid scintillation laboratory for measurement of organically bound tritium (OBT). Samples are kept in a dry place.

For the monitoring of fauna and flora of the estuary and marine environment, a sufficient amount of algae material is collected in areas that are flooded by high tide, but accessible for harvesting during low tide. The samples are stored in a plastic bag. A sufficient amount of shrimp and shell fish is also collected.

A ship collects fish samples at predetermined locations. Samples are frozen and collected in Oostende when the ship has competed its task.

5.4 MONITORING OF RADIOACTIVITY IN FOOD

5.4.1 Milk

Monitoring the food chain in Belgium includes weekly sampling of milk from supermarkets and dairies (Fig. 22), which collect from a large number of farms (several thousands in Flanders and Wallonia).

Weekly weighted average samples are prepared by mixing samples collected over one week from each region. For fresh milk samples there is one sample a week for gamma spectrometry and one every four weeks for ^{90}Sr analysis from each sampling location. The frozen week sample is stored at a temperature < -5°C. Samples are stored in a dark and dry place until one month after the submission of the quarterly result report. These samples are transferred into an appropriate beaker and sent to the lab for a gamma spectrometry measurement. The radioisotopes analysed are $^{134-137}$Cs, ^{131}I, ^{40}K and ^{90}Sr.

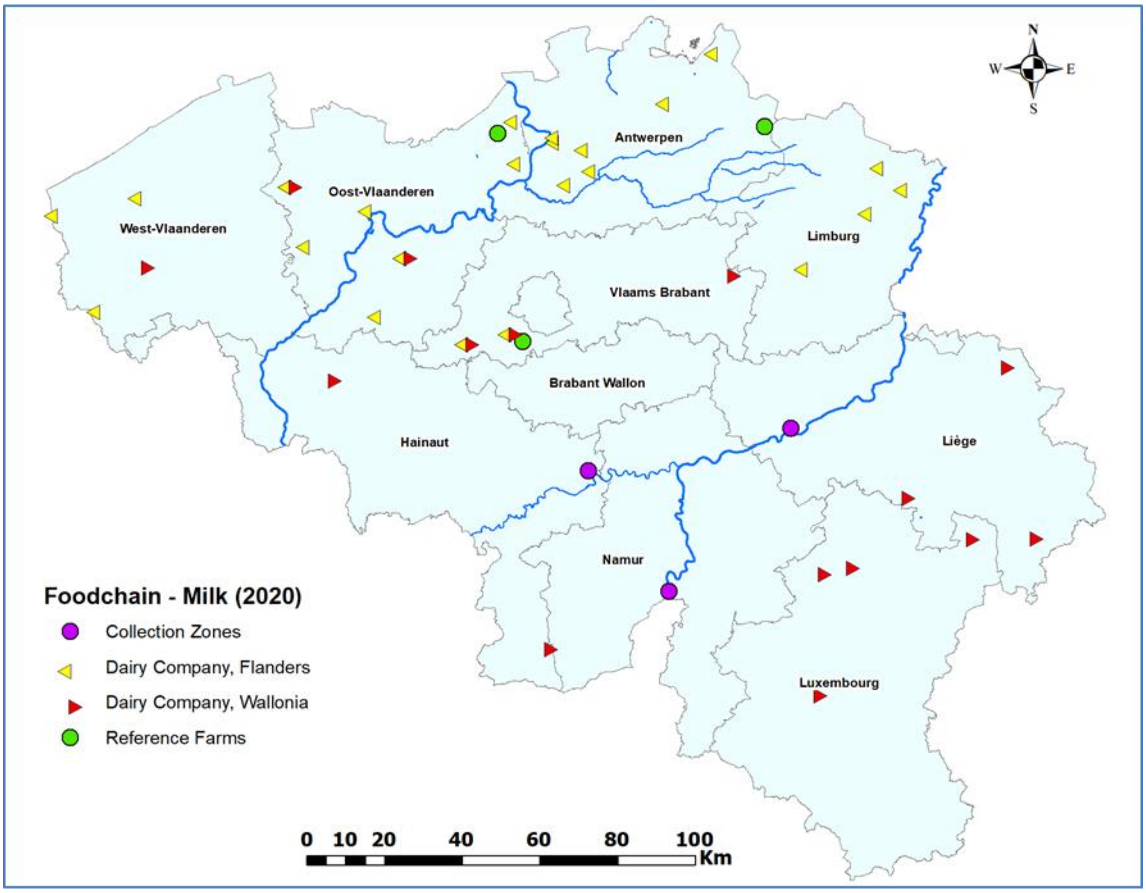

Figure 22. Milk collection zones

5.4.2 Mixed diet

Samples of mixed diet are taken from canteens on a monthly basis for each region of Belgium (Brussels region, Flanders and Wallonia) (Fig. 23). Breakfast, lunch and dinner representative for an average person daily meals are collected in a local restaurant or a boarding school.

All meals (solid and liquid) are grinded to homogeneity and freeze-dried or dried at 40°C. From the homogenised sample, an appropriate beaker is filled with the sample for gamma spectrometry measurement. Active charcoal is added to the sample to trap Rn and the sample is kept for a minimum 3 weeks to allow equilibrium and then measured.

Each 3 months, ^{14}C and ^{90}Sr measurements are carried out on the meals. A separate part of the dried sample is used to prepare a trimestrial sample by mixing a portion of the three monthly samples. A portion of dried trimestrial sample is taken for measurement of organic ^{14}C. Another portion of this sample is then calcinated at 550°C for 24 hours and transferred to the laboratory for measurement of ^{90}Sr.

One sample a month for each sampling location is stored for the time needed for the preparation of the trimestrial sample. The residual trimestrial sample is stored in a dry place one month after the submission of the quarterly results report.

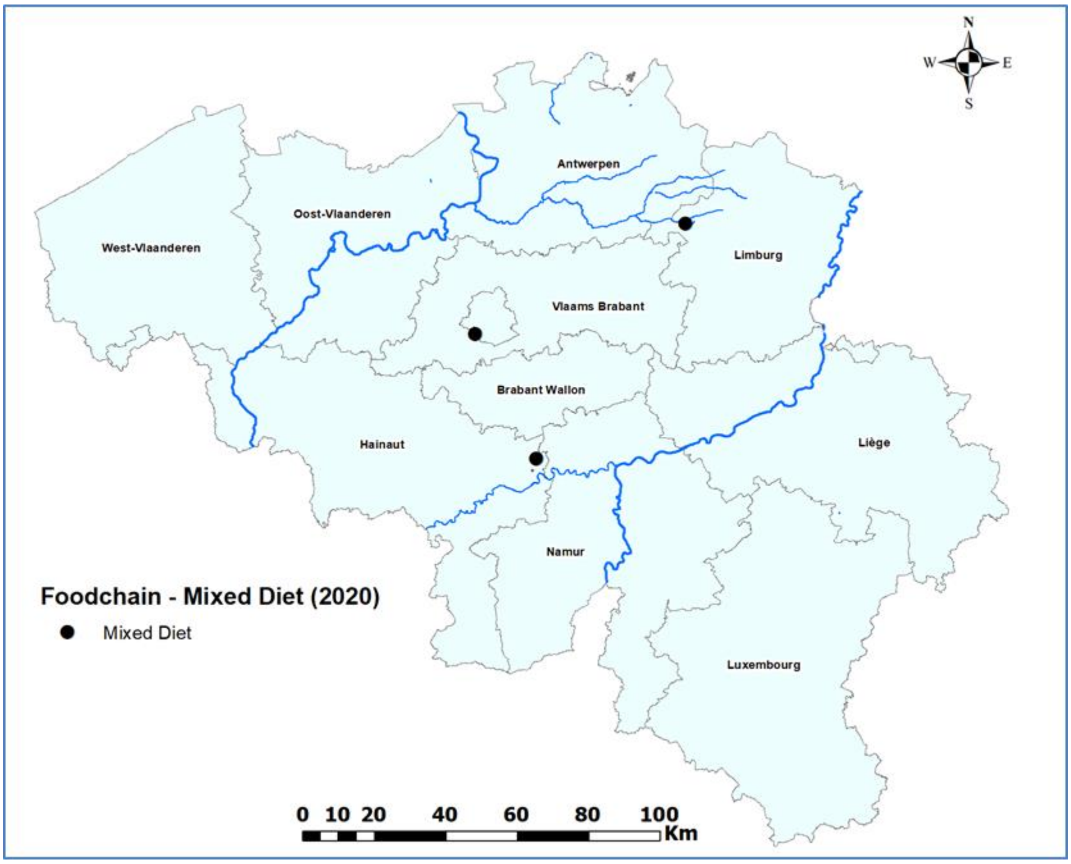

Figure 23. Locations for collection of mixed diet samples

5.4.3 Foodstuffs

Samples of different foodstuffs are collected on the national territory by targeting small retail outlets and supermarkets, markets, abattoirs, fishmongers, etc. (Table II). Sampling of food chain products is done once every month by buying seasonal products at the local markets (meat samples, fish samples and vegetable or fruit samples). The sampling includes the following:

- Common staple vegetables (lettuce, leeks, celery, cauliflowers, Brussels sprouts, white cabbages, red cabbages, broccoli, beans, carrots, chicory, asparagus, tomatoes, cucumbers, peppers, salsifies, turnips, eggplant, zucchini, spinach, beets, fennel, pumpkins, onions, rutabagas, potatoes, cultivated mushrooms, wild mushrooms, etc.).
- Common staple of fruits (pears, apples, nectarines, kiwis, plums, mangos, melons, oranges, bananas, berries, strawberries, blackberries, grapes, etc.).

- Meat from markets and abattoirs (beef, veal, horse, pork, sheep, goat, rabbit, lamb, poultry (including chicken, turkey, pheasants, ducks, geese, ostriches, etc.), roe and wild boar in season). Snails and frog legs are also controlled.
- Fish from fisheries (fresh water fish (tilapias, silurids, etc.) and deep-sea marine fish (tuna, swordfish, bream, bass, cod, herring, whiting, ray, sea trout, mullet, ocean perch, pollack, salmon, etc.) and fish living on the bottom (plaice, sole, etc.)).

Each sample is sliced into smaller pieces and (freeze) dried. The weight of the sample is registered before and after drying. Each dried sample is grinded to homogeneity and a mixed sample is made from the homogenized samples. A container is filled for gamma spectrometry measurement. For the ^{226}Ra activity determination, measurement is performed on its gamma emitting daughter nuclides (^{214}Bi and ^{214}Pb) after an ingrowth period of minimum 2 weeks. In this particular gamma measurement, radon loss has to be avoided. Radionuclides assessed are presented in Table II.

A mixed quarterly sample is also prepared. These quarterly samples are calcinated at 550°C and transferred to the lab for measurement of ^{90}Sr. The residual dried samples are kept in a dry place.

Table II. Radiological monitoring programme for foodstuffs

Zone		Location of sampling points	Type of measurement	Frequency of sampling
Foodstuffs	vegetables meat fish various (mushrooms, flour, etc.)	national territory among small and large scale retailers	Spectrometry of which $^{134-137}$Cs, ^{40}K ^{90}Sr	4 samples monthly of meat, fish, vegetables 4 samples annually of meat, fish, vegetables
	control meal	company canteens: Mol (SCK CEN), Fleurus & Brussels (CARREFOUR)	Spectrometry of which $^{134-137}$Cs, ^{40}K ^{90}Sr and ^{14}C	monthly quarterly

5.5 MOBILE MONITORING

5.5.1 Mobile on-line dose rate monitoring

FANC has 23 GammaTracer XL2 mobile stations, which have been supplied by Saphymo in 2004, for use within the framework of emergency planning (Fig. 24 and 25). These probes are maintained by FANC; deployment of the probes can done by the Belgian Civil Protection and/or by FANC.

In routine mode, the probes have a transmission to the server once a day with a measurement cycle of 1 hours. In this configuration, the autonomy is above 1 year.

The probes have also a wake-up threshold of 200 nSv/h. Above this threshold the measurement cycle and transmission cycle is 10 minutes. In this configuration, the autonomy is reduced to few weeks. The location of the probes is given by a GPS sensor; coordinates are sent with each data transmission.

An alarm test is performed every 3 months and once a year general maintenance is done (battery inspection, checking parameters, calibration, etc.).

Data from the mobile stations is handled by the PANORAMA system. The GPS location of the stations is automatically refresh and displayed in the system.

Figure 24. Mobile dose rate monitoring station GammaTracer XL2

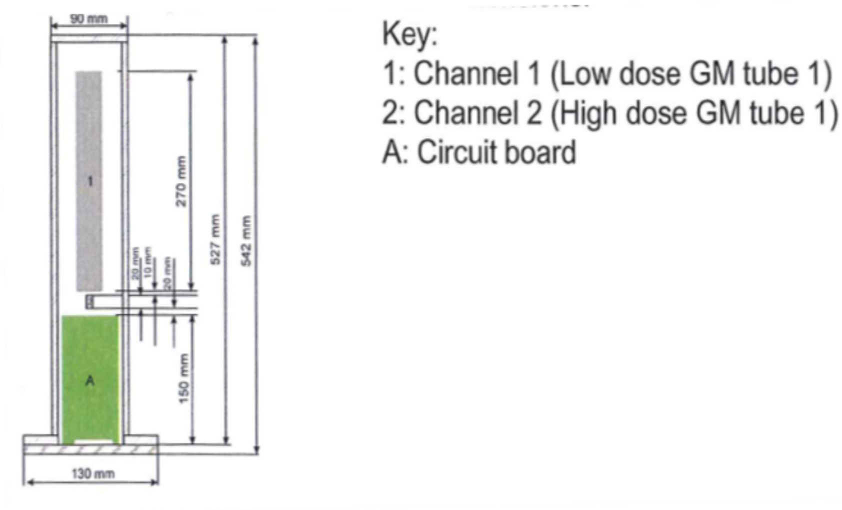

Figure 25. GM-tubes of the mobile gamma dose rate monitor

5.5.2 Terrestrial monitoring

Both IRE and SCK CEN have vehicles equipped for mobile terrestrial radioactivity monitoring. The cars are equipped with personnel protective equipment, equipment for sampling, gamma monitors and decontamination equipment, computers and UPS's. In addition, the equipment set can include a portable air sampler with dust and charcoal filters (Fig. 26).

Figure 26. Portable air sampler

5.5.3 Airborne monitoring

Two airborne monitoring systems are available in Belgium, one operated by the IRE in Fleurus and one by the SCK CEN in Mol (Fig. 36 and 42). Both systems are based on an AGS system, which can be mounted on a helicopter. The AGS system has 4x4" NaI detectors with electronics and a computer. It can operate 3-4 hours on a flight. The AGS system measures dose rate and gamma spectra with position and altitude information.

Drones equipped with detectors have been developed by the SCK CEN (Fig. 27). The drones can fly over an area to establish radiation hot spots. Maintenance and operation of the drones is assured by the SCK CEN. A customized software is used for receiving and analysing data from the drones. The drones can have mounted a CsI detector or a Si multiplier tube for nuclide identification.

Figure 27. SCK CEN monitoring drones

5.6 INFORMATION FOR THE PUBLIC

Data from the on-line monitoring systems is published in real-time through the TELERAD website[6], while an overview of the results of the offline programme, together with interpretation and conclusions, is published in the form of a yearly reports on the FANC website[7].

The raw data of the offline monitoring programme is currently not made available to the public, but can be obtained on a specific request. An on-line database to make these raw data available to the public is foreseen in the near future.

The nuclear operators have the responsibility to communicate to the public both during routine and emergency situations.

In the event of an emergency, overall communication with the public is the responsibility of the governmental crisis management team. Information to the population goes via media and official websites of FANC and the Crisis Centre. Information compiled from the radiological monitoring programmes is made available to the public via the Crisis Communication Cell, FANC being responsible.

The dose rate readings received from the automatic monitoring systems are made available at the EC EURDEP website with no delay.

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6 www.telerad.be

7 https://fanc.fgov.be/fr/publications/rapports-de-surveillance-radiologique-de-la-belgique

6 BRUSSELS AREA MONITORING

6.1 GENERAL

Environmental radioactivity in the city of Brussels is monitored as a part of the national monitoring programme. There are no nuclear facilities in the Brussels region, but in the event of an emergency in one of the NPPs in Belgium or in neighbouring countries close to Belgium, a radioactive release could reach Brussels in a few hours.

6.2 AUTOMATIC MONITORING

The automatic radiation monitoring in Brussels (Fig. 28) consists of the following stations:

- Air collector at the FANC headquarters (TELERAD AER/B01). This is an automatic station for monitoring radioactivity in air, including radioactive iodine (see section 5.2.6).
- Dose rate monitors at FANC headquarters and Dilbeek (IMN B01 and IMN M03) (see section 5.2.3). These are standard dose rate monitors of the TELRAD network

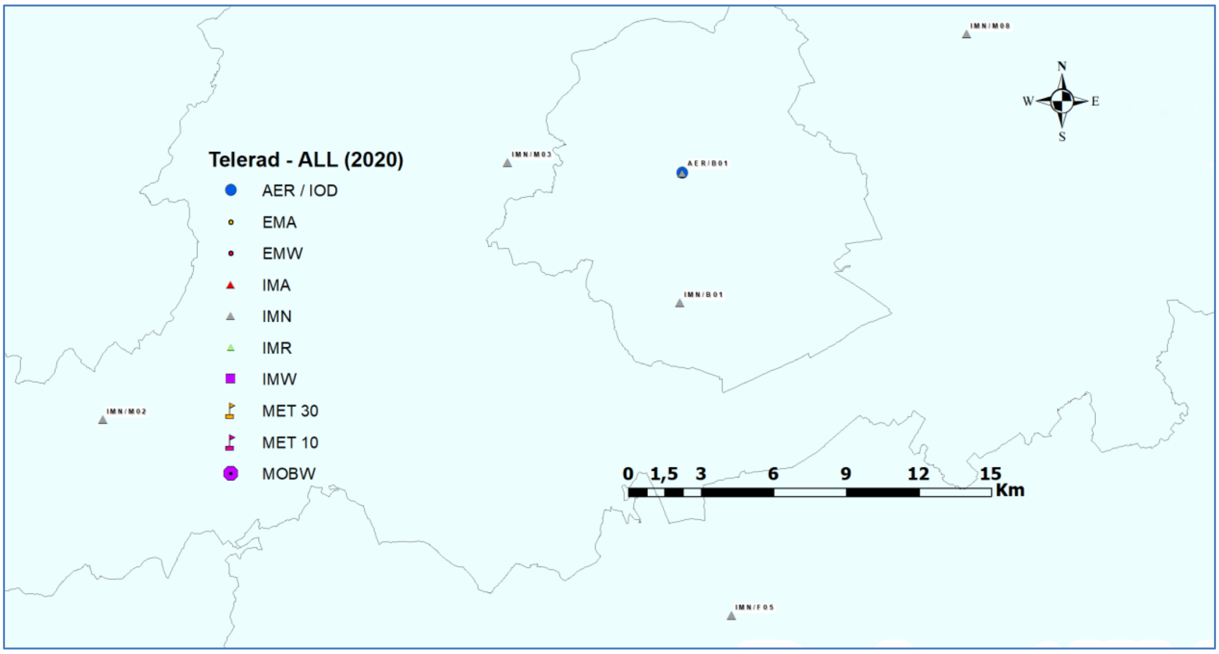

Figure 28. TELERAD network at the Brussels area

6.3 ENVIRONMENTAL SAMPLING

6.3.1 Surface water

There is no routine monitoring of surface water in Brussels. Surface water is sampled occasionally in Brussels from few sampling points and analysed by the SCK CEN.

6.3.2 Ground water and drinking water

Brussels tap water is ground water from the Walloon and Namur areas. There is a routine monitoring programme for drinking water in Belgium and in Brussels. In Brussels one sample, taken from Uccle is analysed every 3 months.

6.3.3 Milk

Daily milk samples are taken and collected on a weekly basis. Samples are pooled and transferred for gamma analysis. There is one milk sampling location in Brussels (the only farm in the city).

6.3.4 Foodstuffs

The national foodstuffs monitoring programme covers also retailers in the Brussels region (local supermarkets such as Carrefour at Drogenbos).

6.3.5 Soil

Soil (grassland) is sampled in one location in Brussels (Royal Metrological Institute at Uccle).

6.3.6 Mixed diet

Samples of mixed diet are taken from a canteen on a monthly basis in Brussels (Lunch Garden at Carrefour Drogenbos). Breakfast, lunch and dinner representative for an average person daily meals is collected.

6.4 EMERGENCY MONITORING

In the event of a radiological emergency, radioactivity monitoring in Brussels mostly relies on the mobile capabilities of the IRE and SCK CEN (and to some extent of the Civil Protection). Both of these have mobile monitoring units equipped with dose rate monitors, contamination survey equipment and air/environment sampling equipment. These could be deployed in the Brussel area in a few hours. In addition, FANC has mobile TELERAD stations, which can be quickly deployed in the Brussels area in order to intensify the automatic dose rate monitoring network.

FANC operates a radiological stand-by service of five persons. In addition, four other FANC staff members have been trained to take part in emergency monitoring if needed.

Brussels city fire brigades are equipped with alarming personal dose rate monitors in order to have an early detection of radiological material presence (orphan source) in accident situations.

7 LABORATORIES PARTICIPATING ON THE ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

7.1 GENERAL

In Belgium there are two laboratories involved in the environmental radioactivity monitoring programme: the Belgian Nuclear Research Centre (SCK CEN) in Mol and the Institute of Radioelements (IRE) in Fleurus. Every four years a specification tender is published, in which the complete radiological surveillance programme is divided into two lots:

- Lot 1: Wallonia, Brussels and the area around Chooz (France)
- Lot 2: Flanders, Brussels and the maritime area

For the current contract, both laboratories participated to the tendering with offers for both lots. IRE performs analyses for lot 1, with the exception of neighbouring nuclear sites and themselves (done by the SCK CEN). The SCK CEN performs the analyses for lot 2, with the exception of neighbouring nuclear sites and themselves (done by the IRE).

7.2 BELGIAN NUCLEAR RESEARCH CENTRE

7.2.1 General

The Belgian Nuclear Research Centre (SCK CEN) is a public institution working on nuclear and radiation research, located in Mol. It is a foundation of public utility with a legal status according to private law, under the guidance of the Belgian Federal Ministry in charge of energy. SCK CEN has more than 800 employees. It holds accreditation by BELAC.

7.2.2 Analytical process

Sample reception

Samples get a unique identification prior to sampling (sampling site, sample type and period). All samples are registered in the central LIMS system when they arrive in the SCK CEN laboratory. The registration involves the use of a set of predefined registration scripts set up following sample types and requested radioactivity analysis. All involved laboratories are then informed about the analyses to perform.

Sample preparation

The sample preparations for each type of matrices (e.g. surface water, dry/wet deposition, milk, soil…) are described in internal procedures and available at the workplaces. Sample treatments (filtrations, evaporation, grinding, sieving, calcination…) are performed on equipment maintained and managed in accordance with the equipment management procedures of each laboratory in compliance with the ISO 17025 standard. Sample preparation consists of various techniques; all aiming to get a representative sub portion of a sample that is in a stable condition so the analysis can be performed. Techniques used are:

- Drying (freeze drying or oven drying) following appropriate drying conditions (e.g. temperature, drying time protocol);
- Milling and sieving chosen to guarantee an appropriate degree of homogenisation for a selected sample size and analysis technique;
- Acidifying to guarantee that radionuclides do not precipitate or adhere to walls of recipients, or that solids in suspension are unwillingly dissolved;
- Filtration following the instructions for different sample types;
- Calcination with predefined calcination protocols for temperature and timing program;
- Microwave destruction with predefined destruction protocols for temperature and timing program;

- Combustion (Pyrolizer system) performed in a controlled atmosphere (oxygen/air) and using predefined protocols for temperature and timing program;
- Fusion (Catanax system) using sodium and lithium borate media to dissolve solid samples (such as concrete and soil).

Equipment used for sample preparation is cleaned after treatment of each individual sample and periodic checks are made by running blank sample material through the installations and by analysing the blank control samples for possible contamination. Additionally, where possible, equipment is subdivided and used for the treatment of predefined classes of samples (e.g. distinction between samples with a higher and lower activity concentration).

All sample preparations are executed according to procedures for which laboratory personnel has been qualified. All critical equipment is registered and subject to periodic maintenance and/or calibration. Most of the laboratory equipment exists in multiple pieces of a same type of equipment to avoid stand still of certain preparation steps in the event of failure of a piece of equipment.

The LRM laboratories of SCK CEN have a controlled area in which samples that have activity concentration significantly above levels of natural radioactivity can be prepared.

In addition to being accredited according to the ISO-17025:2017 quality assurance management system, the laboratories of LRM are also ISO 14001 certified and high attention is paid to a correct waste management and to the minimisation of dangerous substances.

Gamma spectroscopy

The SCK CEN laboratory has several HPGe-detectors in lead shieldings (currently 18 in use). All detectors are connected to a LYNX multi-channel analyser (Mirion). The detectors are operated in a dedicated counting room with controlled environmental conditions. Detectors are calibrated for various counting geometries using a combination of experimentally set up calibrations with standard multi-gamma sources (traceable to national standard) and computational techniques (using the EFFTRAN efficiency transfer code). The computational techniques are used to correct for sample filling height, sample density and sample composition for each individual sample deviating from the reference.

Each detector is subject to a quality control program (weekly and monthly checks of various parameters). SCK CEN has in-house knowledge for many maintenance tasks, such as restoring the vacuum of the detector, testing and resolving electronic issues.

Standards used for calibration purposes are made using reference solutions of certified radioactivity of radionuclides. Standards are obtained from different providers (NPL, PTB, Echert & Ziegler) from which a certificate is requested. Using dilutions of the reference activity different volume sources are prepared in-house to set up the reference calibrations for a water matrix. Calibrations for solid sample materials and samples of other materials and compositions are based on the principles of efficiency transfer.

Genie 2000 software is used to analyse the spectra, to identify the radionuclides and to compute their activity or activity concentration. The reference efficiency calibrations used by Genie 2000 are corrected for each individual sample using efficiency transfer principles. Efficiency transfer corrects systematically for sample filling height and sample density (and composition) for each of the predefined reference calibrations. Next to efficiency transfer, also background corrections, decay corrections and true summing corrections are systematically applied. The results obtained in Genie 2000 are directly transferred from the analysis software to the LIMS including raw data of peak areas. Detection limits are computed according to ISO 11929 (involving all the relevant uncertainty components).

Alpha spectroscopy

SCK CEN carries out alpha-spectrometry using PIPS detectors in vacuum chamber (64 in use). The alpha spectrometry systems (Mirion and Ortec) consist of several alpha counting chambers combined in modules/analysers connected to a manifold with vacuum pumps to create the vacuum in the counting chambers. The analysers are grouped and connected to two separate networks and computers, which control the spectrum acquisition. All alpha spectrometry instruments are operated in a dedicated counting room with controlled environmental conditions.

Detectors are calibrated using counting planchets containing known quantities of specified actinides. The actual total efficiency (chemical yield + detection efficiency) is obtained in each separate measurement based on the counts in the tracer peak. A specific tracer is added to the sample material prior to chemical separation. Tracer solutions are obtained from standard solutions with certificate. Since analyses are always relative to the tracer activity the method is robust and not influenced by slight deterioration of the counting efficiency of the detector. The tracers are selected according to the actinide to analyse.

Each detector is annually controlled for its counting efficiency. Tracer activity is chosen in quantities in line with the expected activity in a sample. Standards are used to produce the solutions to spike samples prior to the chemical separations. The spike is added by measuring the volume of the spike solution.

Microwave digestion and fusion techniques are used to dissolve solid samples. Chemical separations are made with different chromatographic techniques selected according to the actinide that is to be isolated. Electrodeposition is used to deposit the radionuclides on the counting planchet.

Genie 2000 software is used to analyse the spectra and to determine the counts in the different regions of interest (ROI). The counts of the ROIs are then entered in a spreadsheet in which the radioactivity is computed (including the chemical yield of the separation). Detection limits are computed according to ISO 11929. The results obtained in the spreadsheet are then transferred to the LIMS from which reporting is made.

Liquid scintillation counting

The SCK CEN laboratory has five Liquid Scintillation Counters (LSC), operated in a dedicated counting room with controlled environmental conditions. The LSCs are calibrated using unquenched scintillation vials containing known quantities of specified radionuclides. Given the large spread in energy of beta spectra there is generally no possibility to deconvolute spectra and to determine several radionuclides from a single spectrum. Hence chemical separation techniques are required to isolate the element and the targeted radionuclide prior to its counting. As a consequence, LSC is generally used to determine a known radionuclide. Several techniques are currently used for this separation.

The chemical yield of the separation is either determined for each analyses by other means (e.g. gravimetrically by the addition of a stable element, by mass spectrometry, or by determination of chemical yield by experiment to fix an average value). Using the method of internal standardisation (where a second measurement is used with a spike added to the sample material); a robust method is obtained that copes with possible quenching effects.

Each LSC is periodically controlled for its counting efficiency and background signal. Certified reference materials (CRM) are used to produce the different spike solutions for internal standardisation. Detection limits are computed according to ISO 11929. The results obtained in the spreadsheet are then transferred to the LIMS from which reporting is made.

Gross alpha/beta counting

The SCK CEN laboratory operates eight Mirion Gross alpha/beta proportional counters. Counters are used to count 11 cm diameter counting trays. Four of these counters are equipped with a sample changer. One module is used for ultra-low level radioactivity measurements; it has four separate trays and requires manual loading of the samples.

The proportional counters are efficiency calibrated with ^{239}Pu for gross alpha counting and $^{90}Sr/^{90}Y$ (in equilibrium) for gross beta counting. Therefore, the gross counting does not yield a true radioactivity measurement (in Bq) since different radionuclides (alpha or beta emitters) emit alpha or beta particles at an energy different from the calibration nuclide. This will result in a different counting efficiency. The thin source method is used for the analyses. For gross alpha counting an absorption correction is applied to correct for the alpha particles lost in the counting due to absorption in the sample layer on the counting tray.

The proportional counters are periodically controlled for their counting efficiency (alpha and beta) and for background. Standards are used to produce the calibration counting trays. Calculation of results is made by spreadsheets in which the counts of the samples are introduced. Detection limits are computed according to ISO 11929. The results obtained in the spreadsheet are then transferred to the LIMS from which reporting is made.

Gross alpha counting

20 gross alpha counters are in use. The counters are homemade using ZnS detectors produced by a special deposition process of the ZnS on a plexiglass disk. The counters are used for gross alpha counting with well-known good alpha-beta discrimination. The detectors are connected to a dedicated set of counters controlled by homemade software that subdivides the counting time in a subset of time frames for which counts are compared for checking the stability of the count (e.g. to detect decay during the counting process).

The ZnS counters are efficiency calibrated with ^{239}Pu. As a consequence, the gross counting does not yield a true radioactivity measurement since with different alpha emitters at slightly different energies slightly different counting efficiencies may result. The thin source method is used for analyses. For gross alpha counting an absorption correction is applied to correct for the alpha particles lost in the counting due to absorption in sample layer on the counting tray.

The ZnS counters are periodically controlled for their counting efficiency and for background. Standards are used to produce the calibration counting tray.

Measurement results

All results are stored in the database of the laboratory LIMS that resides on a SCK CEN network server. Detection limits and decision threshold are evaluated as outlined in ISO 11929. Results are archived at least once every month and stored on a network server. Proper back-up procedures are in place to safeguard the data. All data are kept for a period of at least 10 years. This includes the raw data of the measurements, as well as all data related to sampling and sample preparation.

Reporting

The results of the radiological monitoring program are reported to the authorities each quarter. The results are extracted from the LIMS and transferred in an excel file provided and updated by the authorities. Each report contains the results of the samples for which all analyses were performed. In the event that a result already submitted is modified, it will be notified to the authorities and highlighted in the report.

Sample storage

Residual sample material and testing portions are preserved for least 1 month after the results have been reported. Preservation is in accordance with the ISO norms that are applicable or following good laboratory principles. Sample preparation is performed on all samples received for analysis in order to homogenize them and to prevent degradation of the samples during the storage time (e.g. adding acid to prevent loss of analyte due to precipitation or adsorption). Samples are stored according to the appropriate ISO norms and kept in dedicated storage facilities, which are controlled for all relevant parameters (humidity, temperature, light). There are facilities for dry storage at room temperature, cooling rooms and refrigerators, freezers and freezing rooms. All relevant parameters in these rooms are constantly monitored and alarms are raised if any of the parameters fall outside the designated working limits. Alarm messages are either sent by e-mail or by SMS text messages to the responsible(s) of the room, or audible and/or visual alarms at the entrance of the rooms are activated.

7.2.3 Quality management

SCK CEN is ISO 17025 accredited (BELAC); it participates in the IAEA ALMERA and in national/international comparison exercises and proficiency tests (IAEA, EC, OSPAR). In addition, the SCK CEN participates yearly in other proficiency tests organised by international organisations (NPL, BfS, ISPRA, PROCORAD, AquaCheck). The head of the laboratory evaluates all results obtained by the different laboratories as soon as they become available. Results that are deviating from the expected value are registered and an investigation is initiated to determine the reason of the deviation, or the source of the error made in order to improve the overall process.

7.3 NATIONAL INSTITUTE OF RADIOELEMENTS

7.3.1 General

The National Institute of Radioelements (IRE) is a public organisation carrying out several functions in the nuclear field. The IRE laboratory (IRE Lab) performs radioactivity analyses on a wide variety of sample types: drinking water, foodstuffs, NORM samples, biological samples and environmental samples.

The IRE laboratory has equipment, infrastructure and qualified personnel that enable to measure low-activity samples. IRE analytical methods are ISO 17025 accredited (BELAC). IRE has also a mobile laboratory mounted on a van with gamma detectors and equipment for taking the samples.

7.3.2 Analytical process

Sample reception

Each sample entering in the laboratories involved in the radiological monitoring program for analysis is control by trained staff. This verification concerns the quality and quantity of the samples taken. The samples are then identified and recorded in a database (LIMS system) with their essential information such as the place of sampling, the type of sample or the period of sampling. Labels are then affixed to the samples and they are stored either in a cold room (<5°C) or in a suitable dry place before processing. Each step of the sample reception is described in the internal procedure of labs and complies with the ISO 17025:2017 standard.

Sample preparation

The sample preparations for each type of matrices (e.g. surface water, dry/wet deposition, milk, soil…) are described in internal procedures available at the workplaces. Sample treatments (filtrations, evaporation, grinding, sieving, calcination …) are performed on equipment maintained and managed in accordance with the equipment management procedures of each laboratory, in compliance with the ISO 17025 standard. Sample preparation consists of various techniques; all aiming to get a representative sub portion of a sample that is in a stable condition so the analysis can be performed. Techniques used are:

- Drying (freeze drying or oven drying) following appropriate drying conditions (e.g. temperature, drying time protocol);
- Milling and sieving chosen to guarantee an appropriate degree of homogenisation for a selected sample size and analysis technique;
- Acidifying to guarantee that radionuclides do not precipitate or adhere to walls of recipients, or that solids in suspension are unwillingly dissolved;

- Filtration following the instructions for different sample types;
- Calcination with predefined calcination protocols for temperature and timing program;
- Microwave destruction with predefined destruction protocols for temperature and timing program;
- Combustion (Pyrolizer system) performed in a controlled atmosphere (oxygen/air) and using predefined protocols for temperature and timing program.

Equipment used for sample preparation is cleaned after treatment of each individual sample and periodic checks are made running blank sample material through the installations and by analysing the blank control samples for possible contamination. Additionally, where possible, the equipment is subdivided and used for the treatment of predefined classes of samples (e.g. distinction between samples with a higher and lower activity concentration).

Sample preparation is done according to procedures for which laboratory personnel has been qualified. Critical equipment is registered and subject to periodic maintenance and/or calibration. Most of the laboratory equipment exists in multiple pieces of a same type of equipment to avoid stand still of certain preparation steps in the event of failure of a piece of equipment.

Measurement results

Detection limits and decision threshold are evaluated as outlined in ISO 11929 e.g. uncertainty components other than the component arising from counting statistics are taken into account.

Data handling and reporting

The samples received in the laboratory are recorded in a database (LIMS), which assigns a unique code to each sample. This LIMS has been checked and validated in order to correspond to the expectations of the laboratory. All useful information for processing the sample is recorded (example: date of sampling, required analyses, etc.). The results of the various analyses are imported into the LIMS via validated import excel files. All the results can then be extracted into an excel file. This database also makes it possible to follow the status of the equipment as well as the personnel qualifications.

Storage

Residual sample material and testing portions are preserved at least one month after the results have been reported. Preservation is made in accordance with the ISO norms that are applicable or following good laboratory principles.

7.3.3 Quality management

Laboratories of the IRE are ISO 17025 accredited (BELAC) and participate in the IAEA ALMERA and in national/international comparison exercises or proficiency tests (IAEA, EC, OSPAR, ERA, Procorad, Aquacheck).

8 VERIFICATIONS

8.1 INTRODUCTION

Verification activities were carried out in accordance with the agreed programme. This chapter summarises the verifications carried out the by the verification team. The team has assessed the monitoring arrangements based on their own expertise and comparison with similar arrangements in other Member States.

The outcome of the verification is expressed as follows:

- A '*Recommendation*' is made when there is a clear need for improvement in implementing Art. 35. These are included in the main conclusions of the verification. The Commission requests a report on the implementation of the recommendations – lacking implementation of a recommendation can lead to a reverification.
- A '*Suggestion*' is made when the verification team identifies an action, which would further improve the quality of the monitoring.

In addition, the team may '*commend'* particularly good arrangements, which could serve as a best practice indicator for the other EU Member States.

8.2 FEDERAL AGENCY FOR NUCLEAR CONTROL

8.2.1 Monitoring programme in Brussels

Verification team verified the monitoring programme in Brussels, as presented by FANC. The system is part of the national automatic monitoring (TELERAD) and the national environmental sampling programme. Environmental sampling and analysis is outsourced on four-year contracts awarded via a public tendering process. Currently the IRE does the sampling and analysis in the Brussels area.

The sampling includes the following:

- Air continuously (one sampler at FANC headquarters)
- Soil
- Biota
- Surface water
- Sediments
- Milk

Emergency monitoring in the Brussels area is based on the mobile and airborne monitoring systems of IRE and SCK CEN. These systems include capability for monitoring gaseous and particulate radioactive iodine. They are not located in Brussels, but can be deployed there within a few hours. In addition, FANC has 23 mobile TELERAD stations for deployment anywhere in Belgium.

No remarks.

8.2.2 Monitoring equipment in Brussels

TELERAD stations

TELERAD system operation was demonstrated to the verification team. Data from the monitoring station is displayed on a VPN remote display application, which combines dose rate and radiation spectrum (SARA stations) data with meteorological data. Nuclide specific display is also possible (10 nuclides). The analysis results can be made available on a public website in 20 minutes.

There are four TELERAD dose rate stations in the Brussels area. The verification team visited the dose rate station on the roof of the FANC main office building (Fig. 29). The station is equipped with a local dose rate display and a back-up battery. There is also a back-up diesel generator in the building. The other stations are within a range of 5 km (Dilbeek, Uccle and Zaventem Airport).

There are no spectrometric TELERAD stations in Brussels. Verification team was informed that there is a plan to move some gamma spectrometric stations from the nuclear site rings and place them in Brussels and in each province.

Mobile TELERAD stations

FANC has 23 mobile radiation dose rate stations (MOB/A) which can be deployed in short time in any location in Belgium (Fig. 29). The stations have a GPS location system; communication is via the Blue Light mobile network (closed authority mobile network). The measurement range is from 10 nSv/h to 1 Sv/h.

Air sampling system

The verification team visited the TELERAD AER/IOD station (Berthold BAI 9100-DG) installed in the FANC main office building (Fig. 29). There are altogether seven such systems operational in Belgium. The system collects airborne dust on a rolling paper filter, which is monitored using a NaI detector. Total airflow is about 25 m^3/h. The filter paper roll is not archived for further analysis.

The system includes also an iodine monitor. The equipment is in the basement of the FANC building; the air intake is mounted at building level 1, about four meters above ground. The equipment is running and in good condition.

The station will be replaced in the coming years and moved to the Royal Meteorological Institute of Brussels in Uccle, as a part of the nuclear emergency plan.

> *The verification team suggests installing at least one TELERAD spectrometric SARA station in the Brussels region.*
>
> *The verification team commends the sophisticated automatic radiation monitoring network solutions in Belgium.*

Figure 29. FANC automatic monitoring equipment in Brussels (TELERAD dose rate station, mobile TELERAD dose rate station and the continuous air sampling system)

8.3 BELGIAN NUCLEAR RESEARCH CENTRE

8.3.1 Environmental radiation laboratory

The verification team visited the SCK CEN radiological laboratory in Mol[8]. The laboratory is very well equipped, sufficiently staffed and has excellent working facilities. The team verified the following equipment and facilities:

- Sample receipt process (sample documentation, LIMS, barcoding)
- Sample preparation and storage rooms (scales, mills, dryers, freezing room and refrigerators)
- Oven room (3 drying ovens, 2 microwave furnaces and 3 furnaces)
- Dry sample storage room (sample sealing with paraffin)
- Gamma spectrometry room (18 HPGe detectors - 13 coaxial detectors and 5 low energy detectors) (Fig. 33)
- Alpha spectrometry room
- Alpha counter room (60 Canberra Alpha Analyst PIPS detectors) (Fig. 31)
- Alpha/beta total counter room (including automatic evaporation system BUCHI)

8 Boeretang 200, 2400 Mol, Belgium

- Radon water laboratory (analysing samples from surface waters, contaminated water and geothermal water)
- Alpha total counting room (20 ZnS detector units)
- Beta counting room (4 Canberra Series 5 alpha/beta counters with automatic sampler changer and 1 Canberra LB4200 proportional counter) (Fig. 32)
- Liquid Scintillation Counting room (3 Quantulus LSC, 1 Tricarb 2900TR LSC, 1 HIDEX LSC) (Fig. 30)

Figure 30. SCK CEN liquid scintillation counters

Figure 31. SCK CEN alpha/beta counters with automatic sampler changers

Figure 32. SCK CEN alpha and alpha/beta counters

Figure 33. SCK CEN gamma spectrometers

The verification team was informed of the procedures and documentation associated with the analytical workflow.

SCK CEN radiological laboratory is ISO 17025 accredited. It regularly participates in several national and international comparison exercises and proficiency tests.

The verification team commends the excellent equipment, facilities and the detailed attention to quality assurance at the SCK CEN radiological laboratory.

8.3.2 Drone monitoring

SCK CEN has developed drones, which can carry radiation detectors and can fly over an area to establish the location of radiation hot spots or radioactive sources (Fig. 27). Maintenance and operation of the drones is organised by the SCK staff. Altogether four drones are available. CsI-detectors are used; these can provide also low-resolution radiation spectrum. Customized mapping software has been developed to receive and analyse data from the drones.

The verification team commends the advanced drone monitoring systems.

8.3.3 Air sampling

The verification team visited the high-volume air sampler SnowWhite on the roof of the EME building, where the laboratories of the LRM are located (Fig. 34).

The flow rate of the air sampler is about 900 m^3/h, which allows for low-level analyses in the micro-Becquerel range. The system includes a flowmeter and a total flow counter. The filter is replaced weekly. Analysis consist of gamma spectroscopy on a folded filter and thereafter Gross-alpha/beta counting of an ashed filter.

No remarks.

Figure 34. High volume air sampler SnowWhite in SCK CEN

8.3.4 Mobile monitoring

The verification team visited the emergency monitoring vehicles of the SCK CEN (Fig. 35). The vehicles (Mercedes-Benz and Renault vans) are equipped with the following:

- Equipment and tools for sampling
- Two air samplers with paper filter and charcoal filter (flowmeter integrated)
- Pb castle and NaI detector for sample screening (radioisotope identification)
- Independent power supply
- Calibration source
- Wi-Fi and computer
- Alfa/beta counter for air filters
- Dose rate meters with telescope extension
- Portable monitoring equipment (dose rate monitor, Canberra Inspector 1000, contamination monitors and neutron detectors)
- Radio communication equipment (GSM with Blue Light Mobile SIM card)
- Electrical generator

The vehicles are on permanent stand-by in Mol. Altogether 20 members of the SCK CEN staff have been trained for mobile monitoring.

No remarks.

Figure 35. SCK CEN monitoring vehicle

8.3.5 AGS system

SCK CEN has a mobile radiation screening system (AGS), which can be mounted on a monitoring vehicle or in a helicopter (Fig. 36). Batteries allow for 3-4 hours of continuous operation. The system uses two large NaI crystals for geographical mapping of the radiation dose rate. In addition, radiation energy spectrum can be retrieved for nuclide identification.

SCK CEN carries out two helicopter training flights each year in order to practise aerial radiation mapping.

The verification team commends the SCK CEN advanced mobile radiation mapping system.

Figure 36. SCK CEN mobile radiation screening system (AGS)

8.4 NATIONAL INSTITUTE OF RADIOELEMENTS

8.4.1 Environmental radiation laboratory

The verification team visited the laboratories of the Institute of Radioelements (IRE)[9]. IRE has activities in production of radioisotopes, production of radiopharmaceuticals and environmental monitoring.

In the laboratories of the IRE 22 employees are working on analysing water samples, environmental samples, agro-food products, biological samples, imported/exported samples, NORM, sludge, industrial waste, waste, water discharge, etc. Half of the activity is devoted to environmental monitoring with eight people working in the laboratories. In total about 9000 samples are analysed annually, about 2000 of them are environmental samples and 700-800 drinking water samples.

The laboratories use LIMS, with two independent systems working in parallel. IRE has ISO-17025 accreditation from 2011 and ISO-14001 (from 2015)/ISO-9001 (from 2007) certifications.

The verification team visited the laboratories of IRE. The main building was in renovation at the time of verification and some equipment was moved from its original place.

IRE operates the following equipment for environmental monitoring (Fig. 37-40):

- Samples blender Retsch (GM 300), drier (CHRIST) and mixer for solid sample preparation
- Distillator, reactor, four pyroxydiseurs for quantitative combustion (not yet in use)
- Portable liquid scintillator (TRIATLER) for Tritium analyses
- ICPPRQ System (ICP-MS) for uranium measurements, ^{226}Ra and validation of ^{99}Tc in drinking water samples
- Equipment for evaporation of samples and extraction of ^{226}Ra, ^{90}Sr, ^{91}Tc on filtered discs (Dry flush chromatography)
- 10 Gamma spectrometers in use (3 with automatic sample changer)
- 2 Alpha counters (22 channels)
- Alpha/Beta counters: one old multichamber equipment (Tenenlec LB4110, 16 channels), two multichamber analysers (Canberra Tennelec Series 5) with one detector each (air filter for direct measurements)
- 3 liquid scintillation counters (Quantulus for determination of ^{90}Sr in food chain and ^{226}Ra in water, Perkin Elmer TriCarb 3180 TR/SL, HIDEX for radon in water and tritium in drinking water
- Hoods, microwave digestion system for determination of ^{90}Sr in milk samples

IRE has a dedicated refrigerated storage room for storage of samples. Ovens and furnaces are located in containers outside the laboratory building.

The verification team noted, that the laboratory facility is cramped and there is no sufficient room for all the equipment and associated material.

The verification team suggests that the IRE increases the room space available for the laboratory, in particular for the counting room equipment.

9 Av. de l'Espérance 1, 6220 Fleurus

Figure 37. IRE container for ovens and furnaces

Figure 38. IRE ICP-MS

Figure 39. IRE gamma spectrometers

Figure 40. IRE Proportional counters for alpha-beta measurements

8.4.2 Mobile monitoring

The verification team visited the mobile laboratory of the IRE installed in a Mercedes Benz Sprinter van (Fig. 41). The vehicle is equipped with the following:

- Equipment for sample collection and a fridge for storing the samples
- Small volume aerosol collector (F&J 50 m^3/h, 30 min sampling time, 2 charcoal filters)
- HPGe-detector with electrical cooling
- Road book with sampling locations (predefined network common IRE/SCK CEN for all nuclear sites)
- Tablets with Blue Light Mobile sim cards (WiFi included)
- Dose rate monitors (3 pc + 1 installed on the roof of the car + specific software)
- Portable contamination monitor
- Electrical generator and a UPS

The vehicle is on permanent stand-by at the IRE. Altogether 16 members of the IRE staff have been trained for its operation.

The IRE has also a van equipped with the AGS System (Fig. 42). The system is identical to the one operated by the SCK CEN. It can be mounted on a helicopter also.

No remarks.

Figure 41. IRE mobile monitoring vehicle

Figure 42. AGS system installed on the IRE vehicle

8.4.3 Atmospheric fallout monitoring

The verification team visited the dry/wet 0.5 m^2 deposition collector installed near the IRE laboratory in the perimeter of STERIGENICS Company (Fig. 43) in Fleurus. The collector is equipped with a heater; samples are collected every week. Sample collection includes rinsing the collector with distilled water. Collector location is good, middle of a large grass area.

No remarks.

Figure 43. Dry/wet deposition collector

8.4.4 Air sampling

On the perimeter of STERIGENICS Company in Fleurus, there is an automatic air sampler installed with seven filters, one for each day of the week (Fig. 44). Technical specifications of the equipment are the following:

- Flow 90-100 m^3/min
- 95-98% efficiency
- GPS/GPRS connection – remote info received by IRE
- Backup battery for the electric part

Seven similar systems are installed in Belgium: close to the four nuclear sites, one in Brussels, one on the coast and one in Lixhe.

A remote control system 'Oasis' has been developed for system monitoring. Four samplers are connected (Tihange NPP site, Lixhe, Uccle and Fleurus). The software is installed in a laboratory, outside the main laboratory building of the IRE (Fig. 45).

No remarks.

Figure 44. IRE automatic daily air sampling system in Fleurus

Figure 45. IRE Oasis air sampler control system

8.5 OTHER VERIFICATIONS

8.5.1 TELERAD station in Fleurus

Close to the main laboratory building of the IRE there is the TELERAD spectroscopic station IMR/F01, which is part of the national monitoring system (Fig. 46). There is another TELERAD station (IMR/F05) on the perimeter of the STERIGENICS Company.

No remarks.

Figure 46. TELERAD station in Fleurus

8.5.2 TELERAD back-up data centre in Fleurus

The verification team visited the TELERAD back-up data centre located in a separate building next to the main laboratory building of the IRE. The building houses TELERAD computers, the back-up servers room and UPS's in order to maintain the network operation in the event of unavailability of the main centre at FANC in Brussels. The facility is equipped with a back-up diesel generator and a UPS. There is also an operational air sampler station (Berthold BAI 9100, identical to the one at FANC in Brussels) and four mobile TELERAD dose rate monitors stored inside the building.

No remarks.

9 CONCLUSIONS

All planned verification activities were completed successfully. The information supplied in advance of the visit, as well as the additional documentation received during and after the verification activities, proved very useful.

The information provided and the verification findings gave rise to the following observations:

(1) Overall, the environmental radioactivity monitoring programmes in Belgium comply with the requirements of the Article 35 of the Euratom Treaty.

(2) The verification activities found that the facilities needed to carry out continuous monitoring of levels of radioactivity in air, water and soil in Brussels are adequate. The Commission ascertained that these facilities are in operation and running efficiently.

(3) The verification activities found that the facilities needed to carry out monitoring of levels of radioactivity in the air, water and soil in the event of a radiological emergency in Brussels are adequate. The Commission ascertained that these facilities are continuously available.

(4) A few suggestions have been formulated. Notwithstanding these suggestions, the verified parts of the monitoring system for environmental radioactivity in Brussels are in conformity with the provisions laid down under Article 35 of the Euratom Treaty.

(5) The team's recommendations are set out in the 'Main Conclusions' document addressed to the Belgian competent authority through the Belgium Permanent Representative to the European Union.

(6) The verification team acknowledges the excellent cooperation it received from all people involved in the activities it undertook during its visit.

ANNEX 1

VERIFICATION PROGRAMME

EURATOM ARTICLE 35 VERIFICATIONS IN BELGIUM 2021

(Brussels city and Belgium inland waters)

12 – 16 JULY 2021

Monday 12 July

14.00 **Opening meeting**

(FANC, Rue Ravenstein 36, 1000 Bruxelles)[10]

- Welcome address
- European Commission Art. 35 verification programme introduction
- Discussion on past verifications in Belgium by the Commission
- Overview of radioactivity monitoring arrangements in Belgium
- Overview of radioactivity monitoring arrangements in Brussels
- Overview of inland water radioactivity monitoring in Belgium
- Overview of the radiological situation at the Umicore factory
- Verification planning

Tuesday 13 July

09.30 **Verifications of radioactivity monitoring arrangements in Brussels**

(FANC, Rue Ravenstein 36, 1000 Bruxelles)

- Dose and dose rate monitoring (TELERAD)
- Air sampling station in Brussels
- Dry/wet deposition sampling station in Brussels
- Mobile monitoring (FANC)
- Iodine monitoring in Brussels
- Sampling (water, soil, foodstuffs)

14:00 **Verification of inland water radioactivity monitoring arrangements in Belgium**

(FANC, Rue Ravenstein 36, 1000 Bruxelles)

- Introduction
- Sampling programme
- Laboratory analysis programme

[10] On 1 January 2022 FANC moved to a new location. The new address is Markies Street 1, postbox 6A, 1000 Brussels, Belgium.

Wednesday 14 July

09.30 **Verification of emergency monitoring arrangements in Brussels**

(FANC + emergency authorities, Brussels)

- Mobile monitoring systems
- Emergency sampling arrangements
- Communication to the public

14.00 **Verification of radiation warning systems in Brussels**

(FANC + emergency authorities, Brussels)

- Presentation
- Presentation/verification visit to the Data centre

Thursday 15 July

09.30 **Verification of SCK/CEN laboratories for environmental monitoring**

(SCK/CEN, Boeretang, 200 - 2400 Mol)

- Environmental laboratory
- On-site measurement systems
- Mobile systems

Friday 16 July

09.30 **Verification of IRE laboratories for environmental monitoring**

(IRE, Avenue de l'Espérance, 1 - 6220 Fleurus)

- Environmental laboratory
- On-site measurement systems
- Mobile systems