The TELERAD network: continuous radiological monitoring of the territory

The TELERAD network is an automatic remote radioactivity monitoring network on the Belgian territory. It comprises 254[1] radioactivity measuring stations which continuously measure the radioactivity of the air and river waters.

These measuring stations are distributed over the entire national territory, around the nuclear installations of Tihange, Doel, Mol-Dessel and Fleurus, as well as in the urban areas close to these installations and in those around the Chooz nuclear installations in France (Figure 1). These measuring stations are linked to a centralized system which is automatically alerted if a threshold level of radioactivity is exceeded.

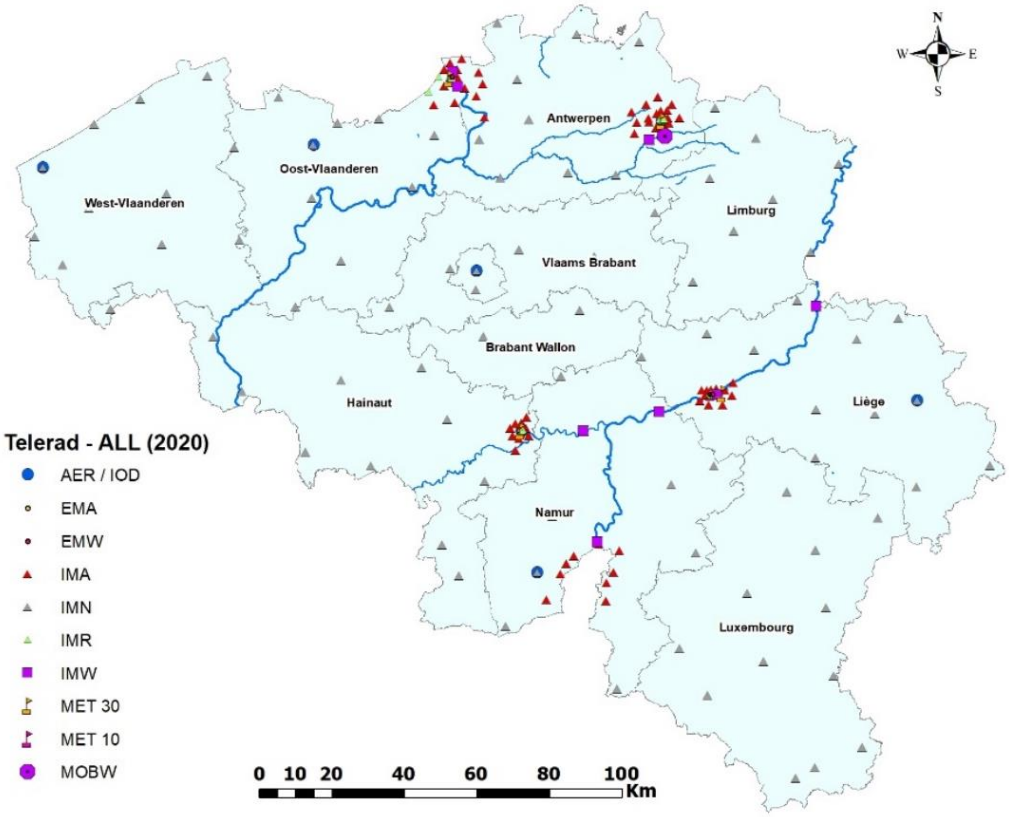

Figure 1. Distribution of the TELERAD measuring stations on Belgian territory in December 2020.

[1] As of 12/31/2020. The number of stations varies slightly from year to year depending on the improvements and modernisations made to the network.

1. Objectives of the network

The TELERAD network is a *measurement and early warning network* which pursues the following objectives:

- The continuous recording of measurements to provide all the necessary statistical information regarding the radiation levels recorded in the country;
- The triggering, without delay, of an alarm to signal the exceeding of a warning threshold.

TELERAD makes it possible to detect, in real time, any situation of increased radioactivity which could lead, in its highest degree of severity, to the triggering of the Nuclear Emergency Plan. In the event of a nuclear accident, TELERAD will play an important role in decision-making, in optimizing the interventions, countermeasures implemented by the relevant authorities as well as keeping the country's citizens informed on an ongoing basis.

This network is an integral part of the **radiological monitoring programme of the Belgian territory**. In fact, radiological monitoring is carried out in three complementary ways:

- **A sampling programme** which is based on numerous periodic samples of several components of the environment (air, water, soil, fauna, flora, food chain, etc.) across the territory, and particularly around nuclear sites, Brussels Capital Region and the Belgian coast, followed by radioactivity analyses;
- **A NORM sampling programme** which is also based on numerous samples, but particularly targets NORM sites, landfills or building materials with enhanced natural radioactivity.
- **An automated TELERAD network** which essentially continuously measures dose rates at numerous fixed points.

2. Radiological instruments

2.1. Air radioactivity

The TELERAD network is comprised of 4 types of stations for measuring radioactivity in the air, classified according to their location and/or operation:

- The **93 IMN** (Immission Monitor for National area) **measuring stations** are Geiger Müller-type dosimetric detectors which measure ambient gamma radioactivity (dose rate, expressed in Sv/h).
  The location of these stations is available in Figure 1. They are spread evenly over the entire Belgian territory, in a grid of 20 x 20 km.
  An illustration of a dosimetric station is given in Figure 2.

Figure 2. Illustration of a dosimetric measuring station that measures ambient gamma radioactivity.

- The **72 IMA** (Immission Monitor for Agglomeration area) **measuring stations** are either Geiger Müller type dosimetric detectors which measure ambient gamma radioactivity or spectrometric detectors (Geiger Müller coupled to a NaI detector) used for the measurement of ambient gamma radioactivity and of certain predefined radionuclides (10 nuclides in routine) (dose rate, expressed in Sv/h).
  The location of these stations is available in Figure 1. They are distributed in the agglomeration (~5 km around the site) of Belgian nuclear installations (Fleurus, Tihange, Doel and Mol-Dessel) as well as on the Belgian territory around the French power station in Chooz. An illustration of a spectrometer station is given in Figure 3.


Figure 3. Illustration of a spectrometric measuring station which measures ambient gamma radioactivity as well as 10 predefined radionuclides.

- The **65 IMR** (Immission Monitor for Ring area) **measuring stations** are either Geiger Müller type dosimetric detectors which measure ambient gamma radioactivity, or spectrometric detectors (Geiger Müller coupled to an NaI detector) used for measuring the ambient gamma radioactivity and certain predefined radionuclides (10 nuclides in routine) (dose rate, expressed in Sv/h).
  The location of these stations is available in Figure 1. They are distributed on the fences around the nuclear sites of Mol-Dessel (SCKCEN and Belgoprocess), the nuclear power plants of Tihange and Doel as well as around the nuclear site in Fleurus (IRE).
  Some spectrometric stations installed in 2018 around Belgoprocess have the particularity of being powered by solar panels and can be moved by means of a trailer.

- The **7 AER-IOD** (AERosol-IODe) **measuring stations** are ZnS detectors which measure the radioactivity of airborne dust (aerosols and fine particles which are collected on a filter) and determine the total alpha and total beta radioactivity, expressed in Bq/m³ (Figure 4, Left). These aerosol measuring stations are supplemented by a unit measuring radioactive iodine on the aerosols and the air particles, also expressed in Bq/m³, when a pre-determined threshold of beta radioactivity is exceeded (Figure 4, Right). If the warning thresholds are exceeded, outside air is pumped into active carbon cartridges, who trap the radioactive iodine, and are automatically measured in order to determine the level of radioactivity.
  The location of these aerosol/radioactive iodine measuring stations is available in Figure 1. They are spread over several locations in Belgium: Brussels, Coxyde, Kluizen, Dourbes, Mol-Dessel and Mont-Rigi.

Figure 4. (Left) Illustration of an alpha/beta unit of measure with a view of the pull-down filter tape that collects dust and particles from the air. (Right) The radioactive iodine detector in its shielding (cylinder) and the parallelepiped tube containing the active carbon cartridges (on the right side).

2.2. Water radioactivity

The TELERAD network also has 2 types of stations which continuously measure the gamma radioactivity of river water. There are 8 IMW (Immission Monitor for river Water) stations and 4 EMW (Emission Monitor for Water release channel) stations in total:

- The **6 Retrofit-type stations** continuously measure the gamma radioactivity of the water (expressed in counts/s and Bq/L). The location of these stations is available in Figure 1. They are installed near the three rivers/streams receiving discharges from nuclear sites and wastewater from major urban centres (including research centres, universities and hospitals) : Meuse, Sambre and Nete **(6 of the 8 IMW stations)**.
  These stations consist of large containers from which river water is pumped to the detector and returns after the radioactivity is measured (Figure 5). Inside is the gamma spectrometry unit (NaI crystal coupled to a multichannel analyzer) housed in a tank, surrounded by a strong lead shielding and protected by a stainless steel casing in which the pumped water flows through. About ten radionuclides are defined in the recognition software.
  To the left of the gamma spectrometry unit is a large volume water sampler (SwedMeter type) which automatically takes samples as soon as an alarm level is exceeded. This water is stored in a 25-litre flask for gamma (and beta) spectrometry analyses in the laboratory.

Figure 5. (Top) Illustration of a Retrofit type measuring station for gamma radioactivity in river water. (Bottom left) Interior of a container with, in the centre, the gamma spectrometry unit and, on the left, a programmable automatic sampler used as part of the radiological monitoring programme of the territory. (Bottom right) Interior of autosampler.

Note that inside the container is also a programmable automatic sampler (Buhler type PP MOS) that pumps continuously river water into flasks for gamma, alpha and beta spectrometry in the laboratory which is used in the framework of the periodic sampling programme in the radiological monitoring of the territory. Figure 5 also shows the inside of the PP MOS, consisting of pumping instruments and collection bottles. This fully programmable unit collects 24/24 7/7 predefined volumes of water over a fixed period of time and a fixed frequency (~ 1 bottle of 2.5 L a day). Above the PP MOS are the measure unit and the high voltage power supply for the detector of the river measuring station.

- The **6 BCI type stations** also continuously measure the gamma radioactivity of the water (expressed in counts/s and Bq/L). They have the particularity of having their probe directly immersed in river water (Figure 6).
  The location of these stations is available in Figure 1. There are 2 stations located in the Scheldt - downstream and upstream of the Doel nuclear power plant **(2 of the 8 IMW stations)** - and 4 stations submerged in the discharge channels of the nuclear power plants to continuously measure the gamma radioactivity of liquid discharges: 1 station in the discharge channel of the Doel nuclear power plant and three stations in the 3 discharge channels of the Tihange nuclear power plant **(EMW stations)**. These stations allow the liquid discharges from electricity production operators to be monitored with close attention.
  They also have an NaI detector which is coupled to a multi-channel analyser. About ten radionuclides can be quickly identified.

Figure 6. Illustration of a BCI type submerged station located in Doel.

Finally, the TELERAD network is supplemented by a set of 23 mobile stations for the measurement of ambient gamma radioactivity (Figure 7). These stations can be deployed throughout the entire Belgian territory depending on the measurement needs.

Figure 7. Illustration of a mobile station for measuring the dose rate (ambient gamma radioactivity).

3. Meteorological instruments

The TELERAD network also has meteorological measuring instruments installed on masts of 10 or 30 m. The location of these stations is available in Figure 1.

- The **4 MET 30 stations** are installed on 30 m masts near the Belgian nuclear sites (Tihange, Doel, Mol-Dessel and Fleurus) and measure wind speed and direction, pluviometry and sunshine. An illustration is given in Figure 8.
- The **9 MET 10 stations** are installed on 10 m masts along the borders and around nuclear sites (Tihange and Chooz) and measure only wind speed and direction.

These data are essential to forecast which regions will be impacted (wind direction) when a radioactive cloud is detected and at what time this will be expected (wind speed).

Figure 8. Illustration of a station installed on a 30 m mast around Belgian nuclear sites (MET 30 station) which measures wind speed and direction, pluviometry and sunshine.

4. Calculation of the external exposure dose rate

Since the TELERAD network measures a dose rate (µSv/h) continuously, it is possible to calculate the annual gamma exposure dose on a station-by-station basis. A mathematical interpolation makes it possible to bring together similar values under the same color and therefore to construct an "isodose map" (Figure 9).

The outcome of such processing leads to the construction of an illustrative map of the natural background due to ambient gamma radioactivity. This background represents the annual exposure expressed in mSv (external gamma exposure dose) to which the territory is subjected. The average gamma exposure dose in Belgium is 1 mSv/year. It varies from 0.6 to 0.7 mSv/year in the north, to 0.8 to 0.9 mSv/year overall in the centre until 1.0 to 1.1 mSv/year in Wallonia, and more particularly, in the Ardennes.

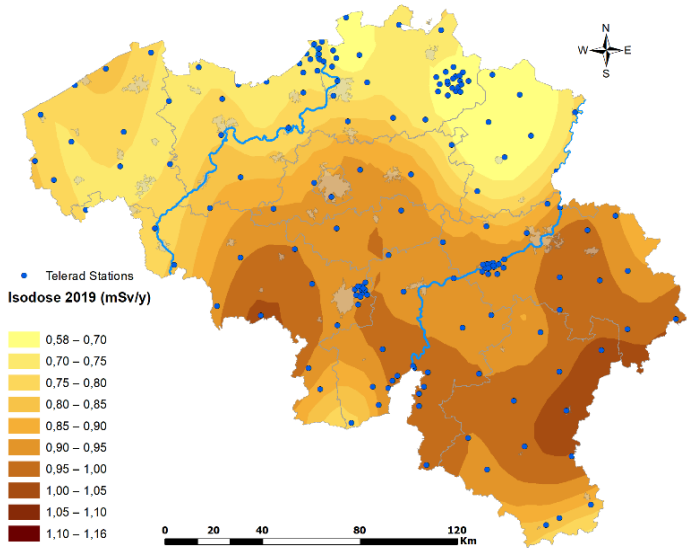

Figure 9. Isodose map of external gamma radiation received on Belgian territory in 2019.

The exposure varies predominantly according to the nature of the soil. The doses are, indeed, generally higher in old terrains made up of rock such as chalkstone, schist, psammite and mixed sands with chalk etc. which is the case for Belgium in the Ardennes and Condroz area (Figure 10). Conversely, the doses are lower in Flanders where the soil is mainly made up of sedimentary terrains (sand, alluvium and clay), the doses are lower. Note that, in the south of the country, i.e. a marly, clayey region with sandy-silty layers over a chalk sub-stratum, the dose declines to reach values comparable to those in the north of the country.

Figure 10. Map of the geology of Belgian soil.

The limit for the dose of ionizing radiation to which the population may be exposed, set at 1 mSv/year, does not take into account the natural radiation linked to cosmic radiation or the radiation of the soil and subsoil or the radiations used for medical purposes. Therefore, it does not apply in this case (natural ambient background).