Environmental radioactivity surveillance system of ANPA

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Abstract No nuclear power station are operative in Italy as a consequence of the general public debate on the use of nuclear energy, stressed by the Chernobyl accident and culminated in the Public Referendum in 1987, but within a distance of a few hundreds kilometres from its border several nuclear plants are operating. In case of a nuclear emergency, for instance, an accident in a transboundary plant, ANPA, National Agency for the Environmental Protection, as the duty to coordinate the technical activities supporting the Civil Protection Agency responsible for the management of national-scale radiological emergency. In this context, the realisation of the ANPA Environmental Radiological Surveillance System was started in 1996. The system was designed for continuous monitoring and early warning purposes and then the airborne particulate was selected as main environmental matrix to be observed. The system is composed of two nation-wide monitoring networks connected to the control centre operating at the ANPA's Emergency Centre; measurements, alarm signals and system status informations are transmitted to the centre in real time for data evaluation, reporting and recording into a data-base and for remote diagnostics of the monitoring station functioning. The ANPA Environmental Radioactivity Surveillance System will be described emphasizing the characteristics of automatic monitoring network.

Key words accidents radiation • emergency • environmental monitoring • radiation monitoring

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Introduction

ANPA is entrusted by the national law, with the operational coordination and the technical support of the CEVaD, Data Processing and Evaluation Centre, the Scientific Committee of the Civil Protection Agency.

To fulfil its institutional mission, ANPA planned the realisation of a modern Integrated Support System with functions of information exchange, early warning, measurement of the radioactivity distribution and estimation of the possible evolution of the environmental contamination.

In this context, in 1996 ANPA started to set up an Environmental Radioactivity Surveillance System for continuous and automatic monitoring of the low-level air man-made radioactivity.

Integrated support system

The integrated support system for decision-taking in the case of radiological emergency was designed to carry out the following main tasks:

– to provide prompt information for reciprocal data exchange among the international and national organizations involved in the emergency management and ANPA, which acts as early notification office for Italy;
– to monitor the main access routes of radioactivity to the national territory and give an early warning for the major nuclear accidents;

- to inform about the actual radiation levels both in an emergency condition and for routine observation of background;
- to forecast the meteorological condition and estimate the radioactivity diffusion on different geographical scale.

The main functional components of the system, running in the Emergency Centre at the ANPA Headquarters, are:

a) A communication system for the link of ANPA, IAEA and all State Parties under the Convention on Early Notification (Convention of September 1986). An automatic system for exchange of information in the case of radiological accidents among the EU Member States (EU Council Decision 87/600/EURATOM), which consists of digital transmission lines operated by automatic coding and decoding programs (ECURIE CoDecS), that alerts a 24 h surveillance service as well as the team of experts who are available within one hour. In case of radiological emergency, ANPA is also the designated responsible for activation procedures of the network of the Regional Laboratories for environmental radioactivity monitoring, managed by local authorities. Recently ANPA has started its participation in EURDEP project (European Union Radioactivity Data Exchange Platform) for the exchange of monitoring data among European Countries with a common data format both in normal and emergency conditions.

b) The computing system ARIES for the real-time acquisition of the meteorological data (by link to the Meteorological Office of the Air Force) for the whole European region. The system carries out two main functions:
   - displaying the weather-forecasting data of typical meteorological conditions, such as cloudiness at altitude and at sea level, rainfall and wind direction and speed at altitude and at sea level;
   - real time calculation of the diffusion of a radioactive cloud and its (wet and dry) fallout onto the territory that can be selected in any European area covering various distances, ranging from a few kilometers to a European scale.

c) The Environmental Radioactivity Surveillance System based on two automatic networks for continuous monitoring of air radioactivity (Fig. 1).

REMRAD is a network of automatic stations, located in Air Force sites, which performs measurements on airborne particulates. The network acts as early warning system (first level network), and includes 7 automatic stations located in places of meteorological relevance which have been chosen with a view to covering the most probable access routes of radioactivity coming from European power plants.

GAMMA network (second level network) with a finer grid of 50 gamma dose rate detectors, placed in sites of National Forestry Corps, with the aim to follow the spatial distribution of radioactive plume all over the Italian territory and to enable a real time evaluation of the geographical coverage of the affected areas.

Both networks are linked in real time and continuously to their respective control centres at the ANPA Emergency Centre, which analyses the measurement results and report any abnormal signals to the operator.

GAMMA network

GAMMA monitoring points are connected to the control centre by a digital telephone link. Figure 2 shows a typical monitoring installation. Each measuring unit is composed of a microprocessor based gamma probe, consisting of three Geiger-Müller counting tubes. Two large volume counting tubes, for low dose level, allow the detection of minor changes in the radiation level, even at low background values within a short measuring cycle. This provides increased detection sensitivity and a higher reliability. The third counting tube is for higher radiation levels.

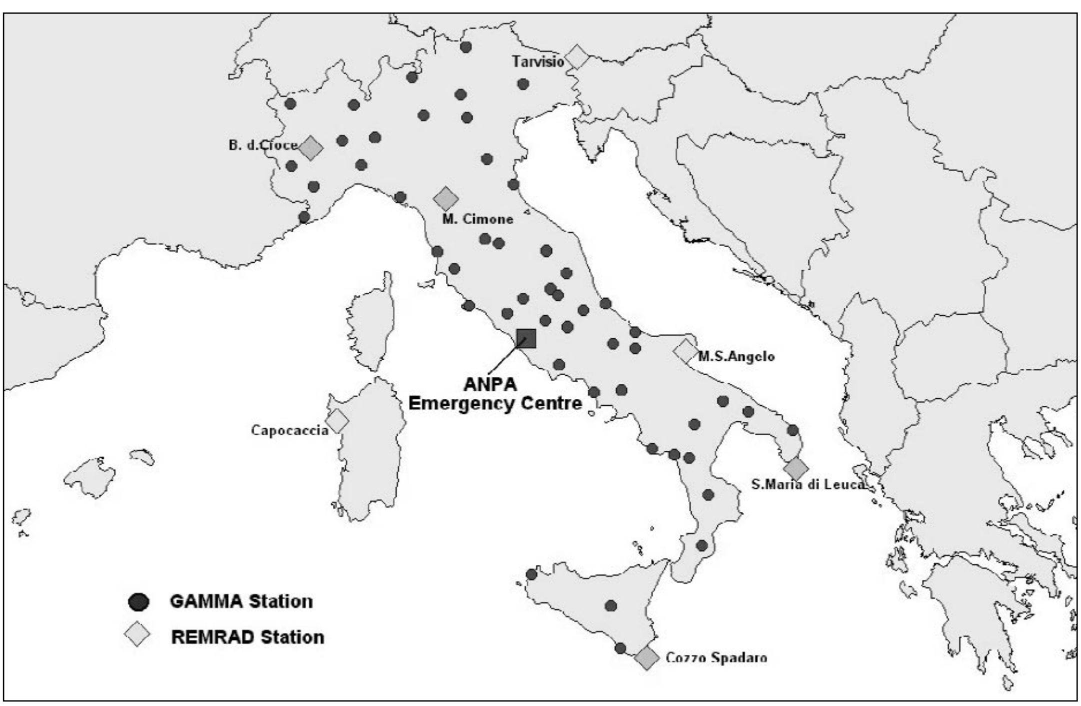


Fig. 1. GAMMA and REMRAD Monitoring networks.

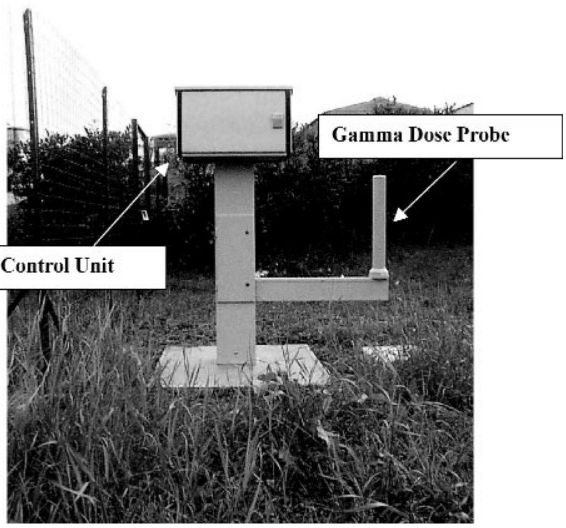


Fig. 2. Gamma dose monitoring unit.

The measurement range is 10 nGy/h – 10 Gy/h for photon energy of 40 keV – 1.25 MeV.

As the gamma dose rate increases with an onsetting rain, a sensor of precipitation presence is connected to the system to enhance accuracy and reliability of the measurement. The probe is connected to a data-logger that performs the local recording and transmission to the control centre.

The main tasks of the control centre are:
– communications among the centre and the remote monitoring stations;
– management of the data-base containing monitoring data, operative parameters, alarm and equipment failure signals;
– man-machine interface that enables the operator to interact in real time with the whole network (Fig. 3).

The control centre interrogates the remote station with a time interval that can be preset for each site. In normal operating mode, the stations are called every hour. During each connection the 10-min and 1-h dose rate measurements are transmitted together with equipment status information. In any case all missing data in the central database are downloaded from a 72 h-buffer of the remote station. This allows the recovering of data after a prolonged failure of the communication network. If the alarm threshold is exceeded, the remote station is able to spontaneously call the control centre, which reacts starting an intensive interrogation cycle of the whole network, updating the radiological field every 10 min. This feature enables to follow the evolution of the radioactive plume in real time.

Warning and alarm thresholds, specific for each site, are pre-settable from the control centre and different data representation can be selected. In Fig. 4 the dose rate trend correlated with the rain presence is shown.

REMRAD network

The basic requirements on which the REMRAD network has been designed as a monitoring system with early warning functions are:
– the fundamental matrix to be controlled are the atmospheric particulates on which the radioactivity can be transported very quickly;
– the monitor should operate continuously and should be able in real time to transmit the information to the control centre;
– the monitoring sites should be distributed to cover all the possible access routes of the radioactive plume to the national territory.

The automatic stations are able to perform the following monitoring functions:
– air particulate sampling on a continuous glass fiber filter tape;
– alpha/beta prompt measurement of both artificial and natural radioactivity of the particulates collected;

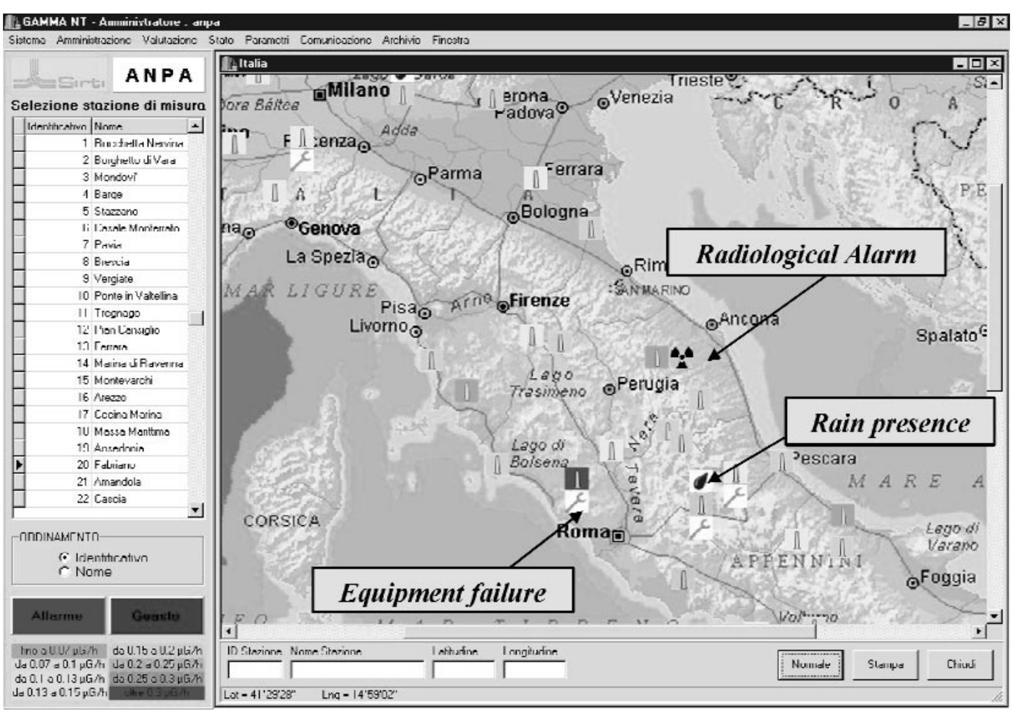


Fig. 3. Graphical user interface of the GAMMA control centre. Close to the site symbols are reported, the icons indicating the eventual presence of rain, radiological alarm or equipment failure.

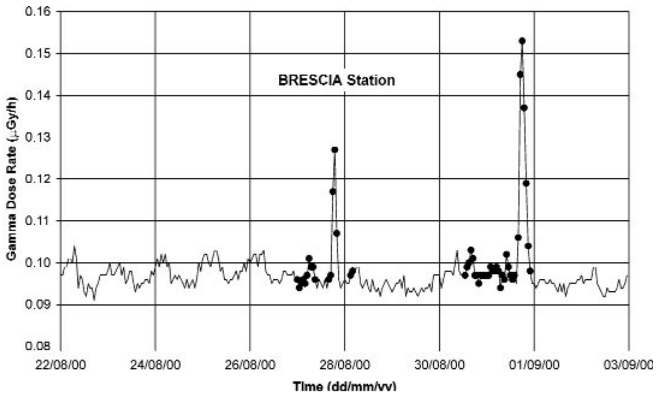


Fig. 4. Gamma dose rate trend where the measurements marked with a dot highlight the rain presence. The rise up of the background level due to the radon daughters washout is emphasized.

– on-line gamma spectrometry analysis by an HPGe electric-cooled detector;
– alpha/beta delayed measurement performed 5 days after the sampling;
– ambient gamma dose rate monitoring;
– measurement of local meteorological parameters.

In Figs. 5a–b typical installations are shown. Each automatic station is composed of the integration of several components: a shelter equipped with air-conditioning unit, the radioactivity monitoring instrumentation, a station control unit which manages the collection, processing and transmission of data to the control centre, a power cabin for the power back-up with a diesel generator and a meteorological unit composed of a set of meteo-sensors giving the local wind speed and direction, temperature and relative humidity, barometric pressure and precipitation intensity.

The radioactivity monitoring equipment (Fig. 6) combines alpha and beta measurements of the particulate collected on a moving filter with gamma spectrometry analysis. A sample of outside air is drawn through a glass fiber filter tape, which retains the particulate. Downstream of the filter, a flow measurement and a lateral blower pump are located. The airflow rate is 25 m^3/h nominal. The alpha/beta detector is a ZnS/plastic sandwich scintillator coupled to a 2” photo-multiplier tube. The separation between alpha and beta disintegration is done by means of energy discrimination. The signals derived from this detector are then further processed to strip the unwanted radon progeny contribution by means of the pseudo-coincidence technique. Five days after, when most of the radon daughters are decayed, the particulate sample is directed into the delayed measuring head where alpha and beta activities are measured.

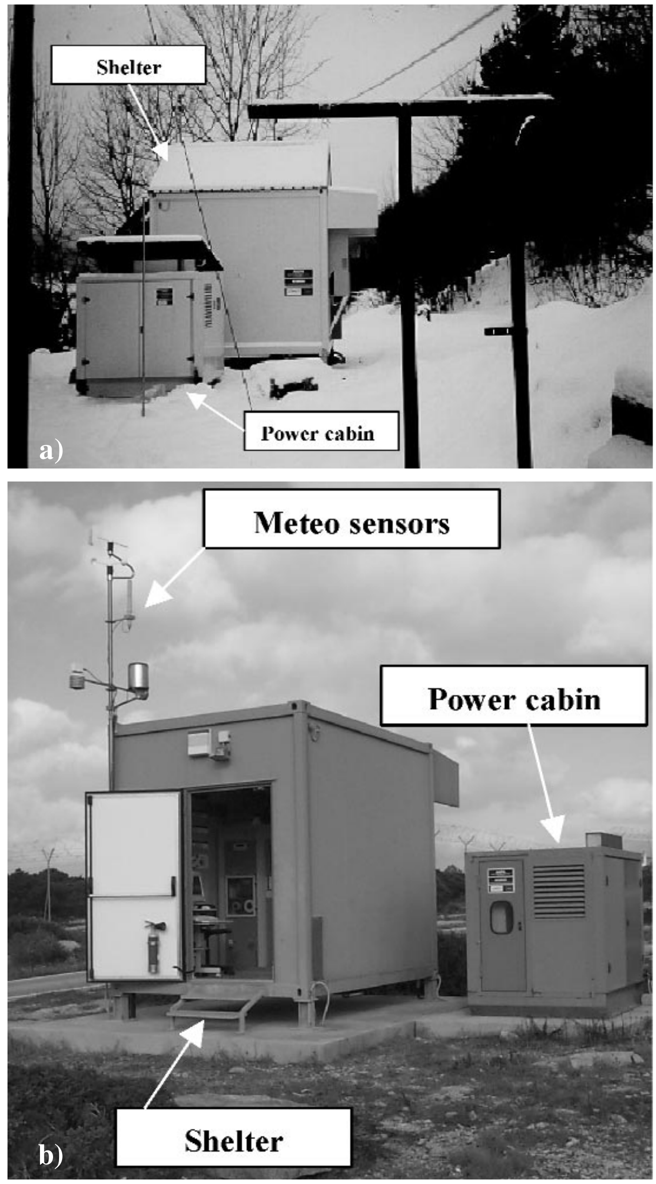


Fig. 5. REMRAD automatic station: **a)** monitoring stations at Tarvisio and **b)** at Capo Caccia.

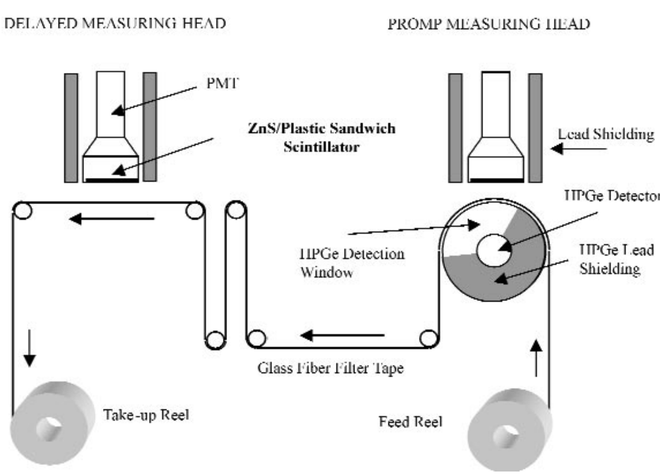
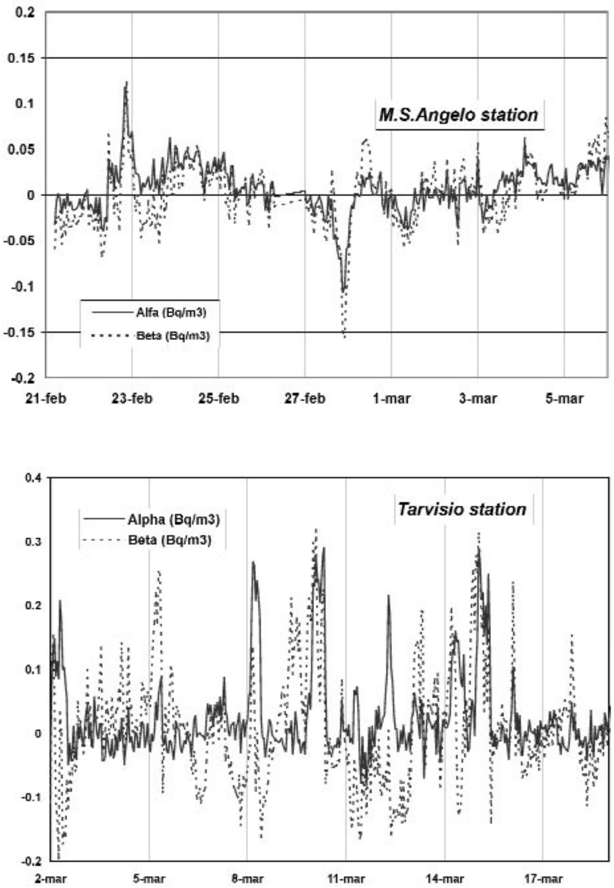


Fig. 6. Functional diagram of the radioactive particulate monitoring system.

The on-line gamma spectrometry system has germanium detector (30% relative efficiency) surrounded with a lead shield. The collimation angle combined with the filter tape speed permits the system to overlook the last 24 h of dust collection and allows to integrate over 24 h the gamma activity present in the sample.

The man-made alpha and beta radioactivity concentrations are evaluated for one-hour measuring time. The theoretical minimum detectable concentration (counts statistics) of the artificial component is less than 0.1 Bq/m^3. The real signal fluctuation depends upon the trend of the natural radioactivity, which is a characteristic of the site. In Figs. 7a–b the trends of the artificial alpha and beta signals (i.e. after background compensation by pseudocoincidence technique) are shown and different values of the alarm threshold have to



a)

b)

Fig. 7. Trend of the artificial alpha/beta signals at **a**) Monte S. Angelo station and **b**) Tarvisio station.

be fixed specific for the two different monitoring sites. To establish the alarm threshold, the local radioactivity measurements (after subtraction of the background), recorded for a long period, are graphically plotted as a frequency or cumulative distribution curves and the threshold value corresponding to a tolerable rate of false alarm is identified.

The detection limits of the delayed measurement are: about 1 mBq/m^3 for alpha measurement and about 6 mBq/m^3 for beta component. Concentrations of gamma-emitting radionuclides are evaluated for a two hour measuring time. Moreover, single 2 h-spectra are added to one 24 h-sum-spectrum to provide a more sensitive measurement. The gamma spectrometry system provides a minimum detectable concentration of about 2 mBq/m^3 of 137-Cs for the two hours measurement time and about 0.5 mBq/m^3 for the daily sum-spectrum.

As an early warning system, i.e. under a sudden increase of the artificial radioactivity in air, the system is able to detect about 40 mBq/m^3 of 137-Cs in a 2 hours elapsed of time.

All measurement results together with the information about the status of the different equipment units and possible alarms are transmitted to the control centre that enables the operator to effectively supervise the operation of the remote monitoring stations. The current gamma-spectrum acquisition can be displayed and a quality control procedure applied to the received data. Moreover, the operator can remotely verify the correctness of the alpha and beta detector response by running a self-test procedure that places a 241-Am/36-Cl test-mixed-source in front of the air-monitor to see the detector outputs and provide information on the eventual re-calibration needs.

Conclusions

Although with some delay with respect to European realities, an automatic radiological monitoring system with early warning function is now operative on the Italian territory.

In case of a severe nuclear accident, the two monitoring networks will detect the arrival of the radioactive plume and its evolution, providing a powerful tool that integrated with the other component running at the Emergency Centre, enabling ANPA to fulfil its institutional mission of technical support to the emergency management.