THE ENVIRONMENTAL RADIOACTIVITY MONITORING IN THE EMILIA ROMAGNA REGION: THE EVOLUTION IN TWENTY YEARS LONG ACTIVITY AND FUTURE DEVELOPMENTS

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INTRODUCTION

The regional structures of environmental radioactivity monitoring had been established as provided in the art. 109 of D.P.R. 185/64, which assigned the control of environmental radioactivity and foodstuffs to Health Minister, and in the subsequent regulations (D.P.R. 4/72, D.P.R. 616/77, L. 833/78)

The art.7 of L. n. 833 of 1978 deputed the Regions to accomplish the administrative functions concerning the control of environmental radioactivity. Such a delegation required to create a monitoring network throughout the regions which allows to evaluate the global impact of the various sources in the area, integrated by controls on each source.

In the Regional Sanitary Plan 1981/83, the Emilia Romagna Region has given the Presidio Multizonale di Prevenzione (PMP) of Unità Sanitaria Locale (USL) of Piacenza (now Agenzia Regionale Prevenzione e Ambiente – ARPA) specific tasks over the whole region related to:

- monitoring the radioactive waste
- analysing and checking complex plants
- monitoring the environmental radioactivity

Further to this task, in 1982 the Settore Fisico-Ambientale of PMP started up a series of initiatives to evaluate the whole of the environmental contamination over the regional area, trying to identify the specific contribution of some sources as well:

- a local network monitoring the environmental radioactivity around the Nuclear Plant of Caorso, which had already been activated in 1980 (before the Plant started to operate), following a convention stipulated between the Provincial Administration of Piacenza and the Emilia Romagna Region and committed to the same Agency;
- measurements of radioactivity in four depurator plants in the province of Reggio Emilia: such a survey aimed at checking the content of radioactivity in the waters and mud getting in and out of the plants, since these matrices would be reused after depuration [(1)];
- evaluation of the liquid radioactive waste from the nuclear medicine department of Ospedale Maggiore in Parma: this initiative, promoted by the Region, was to estimate the radioactive contamination in the sewers caused by the growing use of radioactive isotopes in medicine and before hospitals started the systematic and separated collection of radioactive waste [(2)];

- radio ecological survey over the Po river and the Adriatic sea in front of the delta: the Po river is considered to be the biggest collector of the polluting burden on the Padana plain; within this survey, several matrices have been taken along the Po from a station upriver the nuclear site of Caorso, in two delta lagoons and at three different depths of the Adriatic sea in front of the delta [3];
- the regional network monitoring the environmental radioactivity [4].

The Health Minister, in the Ministerial Circular 2/87, had issued some directives about the executing of environmental radioactivity controls in order to unify and coordinate the initiatives in this field; methods, criteria and standards for controls are enclosed.

A great change in the setting of regulations happened when the controls on environment has been committed to the Environmental Agencies, set up through L. 61/94.

The art. 104 of D.Lgs. 230/95, and subsequent changes and integrations, has committed the control of environmental radioactivity to Environment Minister, while that of foodstuffs and drinks to Health Minister.

THE REGIONAL CONTROL NETWORK OF ENVIRONMENTAL RADIOACTIVITY

The network, organized at regional level, has been made according to the data, disaggregated as to province and provided by the Agricultural Department of Region, concerning the use of the territory and water resources, the productions and the areas of the main crops, the livestock and the processing industries.

In 1982, the main useful pieces of information were [5]:

- over 52% of agricultural area consisting in sown ground (fodder, cereals, sugar beet), 10% consisting in arboreal cultivations, 8% represented by fields and grazing grounds and 18.2% by woods;
- as to livestock, cattle breeding was equal to 14.5% of the Italian amount, pig farming equal to 25%, while sheep and chicken farming was unimportant;
- agricultural production contributing to 14% of the national sales, 48% of which came from cattle-breeding, 27% from herbaceous and fodder cultivations, 25% from arboreal cultivations (fruit and grapevine);
- active agroindustrial sector: production of wine (1/5 of the national product), fruit and vegetables, sugar beets (47% of the national product), meat-processing (20% of the national product), dairy farming (16% of the milk processed in Italy, and 35% of the national consumption) with typical production of “parmigiano reggiano”.

From these pieces of information 22 matrices were at first identified, whose collecting points were chosen on the base of provinces with the greatest production, and sampling were committed to Servizi Igiene Pubblica and Servizi Veterinari of USL.

The programme was largely modified in the years after the Chernobyl accident owing to the issues raised by that event.

Up to that time, the radiometric analyses had been carried out on individual samples: throughout the years 1986/87 there was quite a lot of laboratory work, with a considerable amount of samples being analysed (over 9000 by Sept. 1987).

As from 1988, a nearly definitive programme was agreed upon passing, for some matrices, to analyses carried out on composite samples, providing for about 1000 measurements of γ spectrometry and 50 measurements of ^{90}Sr a year.

The results of the agriculture census in 1990 [6] allowed us to analyse in detail the most meaningful trends under way in the agricultural structures of Emilia Romagna and confirmed the peculiarity of the region's agriculture with respect to Italy and Europe.
The following pieces of information have been sorted out, which confirm the previous situation:

- a high percentage of sown ground (74.5%) with a low incidence of permanent fodder plants due to the limited extension of the mountain area, the amount of permanent arboreal cultivations greater than the CE average, but smaller than the Italian average owing to the region's strong specialization in fruit growing;
- in Emilia Romagna you find 25% of Italy's total amount of pigs, reared in highly-specialized structures with a high average number of animals per farm: 171 animals vs. 24 of Italy's average and 63 of the CE average;
- as to employment, which affects industrial production, in the region job specialization is related to the territory, with strong localization of some activities in well-defined sites: for instance, meat production and meat processing in the provinces of Modena and Parma, dairy farming in the provinces of Parma and Reggio Emilia, vegetable preserves in the provinces of Parma and Piacenza, pasta in Parma and Bologna, wine production in the provinces of Reggio Emilia and Modena.

The updating of the agroindustrial situation of Emilia Romagna, referring to 2001 [7], together with the proposal contained in the revision plan of the national network [8] will provide an essential information ground to define the criteria needed to reorganize the control over the environmental radioactivity in the region.

Tab. 1 shows the programme of controls in 2002.

Tab. 1 – Programme of controls in Emilia Romagna in 2002

matrix	frequency	province
Atmospheric particulate	hourly	Pc
Air dose-rate	continuous	Pc
Fall-out	monthly quarterly (Sr90)	Pc
Fodder	Apr-Oct	Re
Surface water	quarterly (also Sr90)	Fe
Sea water	half-yearly	Fo
Sea sediments	half-yearly	Fe, Fo
River sediments	half-yearly	Fe
DMOS	half-yearly	Pc, Fe
Periphyton	quarterly	Fe
Molluscs/Mussels, sea fishes	quarterly	Fo, Rn
Fresh water fishes	quarterly	Pc, Fe
Drinking water	half-yearly quarterly (Sr90)	Fe
Vaccin milk	monthly	Re
Industrial milk	monthly quarterly (Sr90)	Pr, Bo Pr
Parmigiano, Grana	half-yearly	Re, Pc
Beef meat	quarterly	Re, Mo
Pork meat	quarterly	Pr
Chicken, rabbit meat, eggs	half-yearly	Fo
Cereals	yearly	Pc, Bo, Fe
Vegetables	yearly (Sr90 in lettuce)	Pc, Pr, Bo (Market), Fo
Fruits	yearly	Bo (Market), Fe, Ra
Pasta - meal	quarterly	Pr, Bo – Bo
Products for babyhood	quarterly (Sr90 in powdered milk)	Pr, Re
Industrial products (wine, jam, sugar and fruit juice)	yearly	Mo, Fe, Ra
Diet	quarterly	Pc

MATERIALS AND METHODS

γ-spectrometry measurements are carried out by means of GeLi and GeHp detectors, with 25-30% efficiency and 1.8 keV resolution at 1332 keV of Co60. Counting times, generally 60000 sec, allow an uncertainty less than 10% at a confidence level of 95% for Cs137 determination.

Sr90 analyses are carried out by means of a low background β counting system equipped with anticoincidence plastic scintillators and 3-4 cpm as background rate. The detection limit, with counting times of 60000 sec, depends on the sample and is, for example, 0.03 Bq/l in milk and 0.01 Bq/m² in fallout.

ANALYSIS OF THE RESULTS

Some of the experimental results of measurements performed within the control network will be illustrated here, pointing out how the monitoring plan allowed us to notice and follow the evolution of accidental situations.

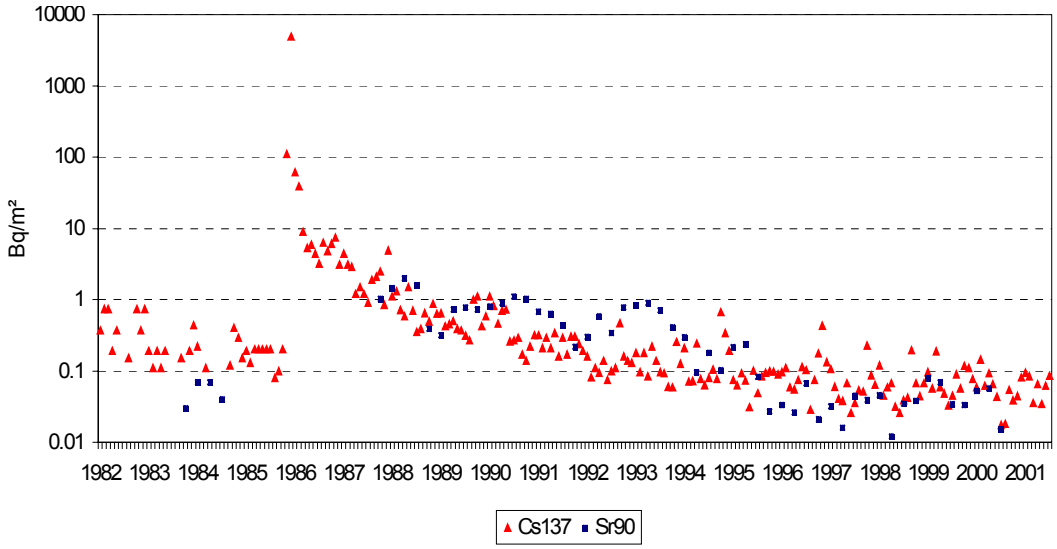
The Chernobyl accident

Among the matrices analysed continuatively since 1982, some considerations related to fallout and milk are reported.

The analyses of fallout allow us to detect radioactive contaminations produced on a planetary scale, such as those caused by a nuclear explosion in the atmosphere. Further to the Chernobyl accident, more than 15 radionuclides, most of which with short half-life, were detected in samples during May 1986. During that month, Cs137 was 4900 Bq/m²; since the accidental event was short, the fallout analyses performed in the next months show a progressively lowering contamination, which, by 1992 and 1996 for Cs137 and Sr90 respectively, was back to the same level as before Chernobyl.

Fig. 1 shows the trend of Cs137 and Sr90 contamination since 1982.

Fig. 1 – Cs137 and Sr90 contamination in fallout



The Cs137 values, measured in the monthly fallout during August 1986 – December 1994 were processed and they could be described by means of a single exponential equation with a half time of 514 days [9].

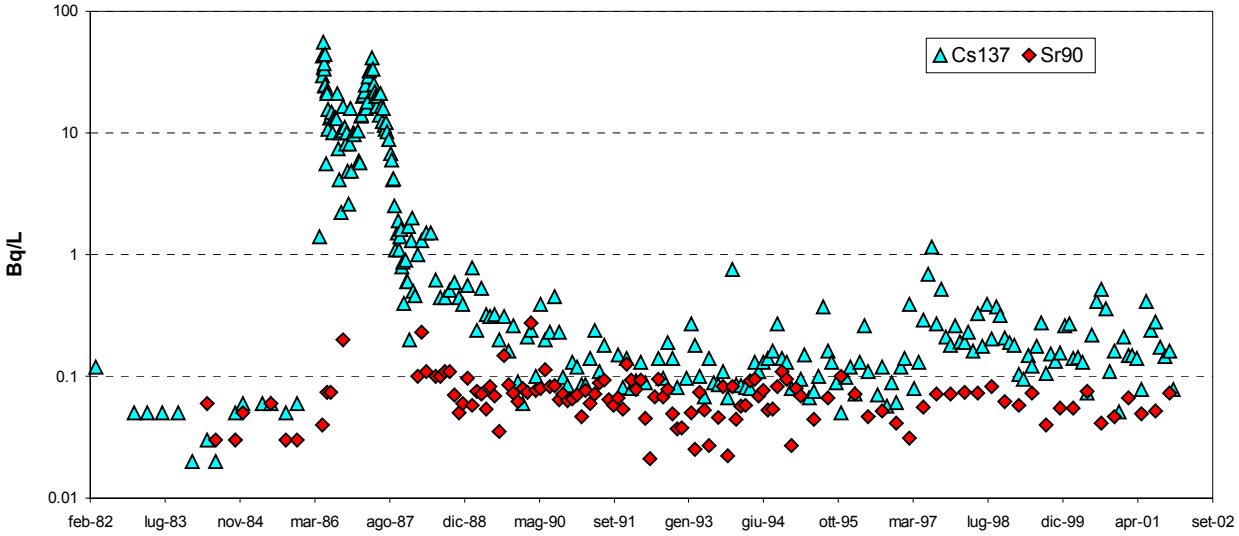
Among foods, the milk is surely of primary importance and contributes significatively to adsorbed dose after a radioactive fallout.

Nevertheless, milk is the first and sensitive indicator of contamination from fallout, as cattle feeding is based on fodder, which picks up in a significant way the deposited radionuclides.

The vaccine milk produced locally in some provinces and the industrial milk produced by the more important industries existing in region has been constantly monitored.

Fig. 2 shows the trend of Cs137 and S90 mean contamination in industrial milk since 1982.

Fig. 2 – Cs137 and Sr90 contamination in industrial milk



In this graph you may note that, after a notable growing of Cs137 immediately after Chernobyl fallout (with hundreds of Bq/L in a few sample), the concentration began to lower caused by both growth and use of fresh fodders, successively reaped.
Such a decay, observed in all kind of monitorated milk, follows single exponential curve with half-life ranging from 22 (vaccine milk) and 69 days (industrial milk). In November 1986, milk contamination grew again, due to animal feeding, during winter months, with contaminated hay reaped during May/June. Since May 1987, as no more contaminated fresh fodder has been almost integrally used, Cs137 concentration began to lower constantly. Analysing this trend from two to eight years after the accident, we estimated a half-life ranging from 600 (milk) and 870 days (industrial milk) [(9)].

The results of analyses provided for in the control network allowed us to estimate the effective equivalent dose, individual and collective, of the Emilia Romagna population caused by the accident.
During the first year after the accident, we considered the contribution from inhalation, irradiation from ground and ingestion, while in the following years the ingestion alone.
Dose assessment from inhalation and ingestion take account of air volume inhalated and the diet habits different by age of population and the average contamination in air and in principal foods of the diet.
The collective dose was estimated in 1348 manSv in 1986, without taking account of countermeasures provided for by the Health Minister, i.e. population was forbidden to eat vegetables (from 3 to 17 May 1986), pregnant women and children up to 10 years to drink milk (from 3 to 24 May 1986); the following year the estimated value was 47% and it is as high as 2 manSv since 1993 [(9)].
During the years following the accidents, population exposure is caused by the ingestion of the caesium isotopes through the diet.

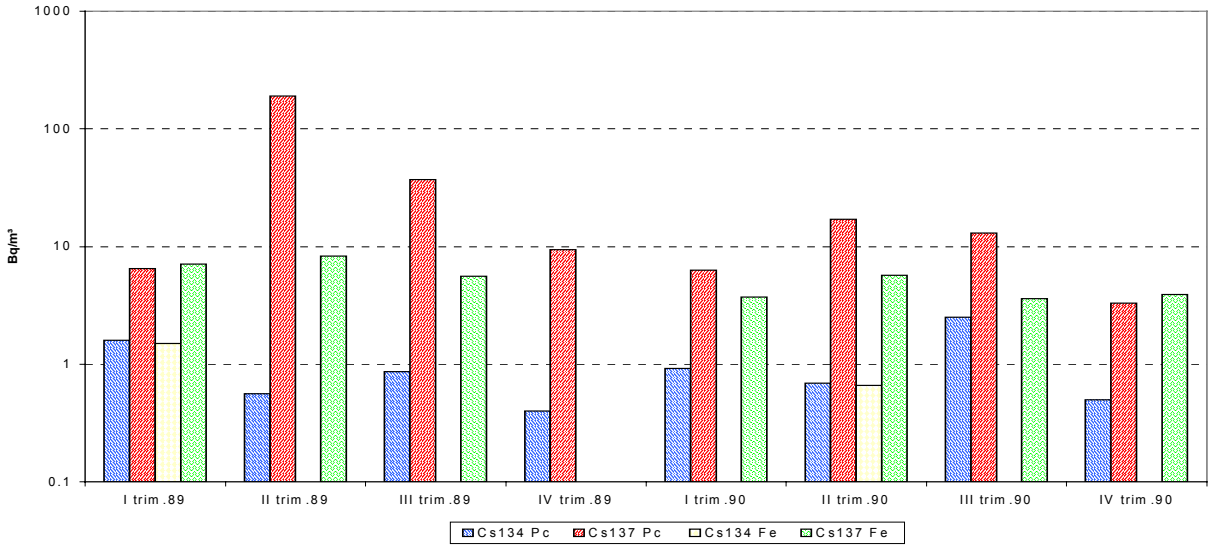
Together with the control activity, the lab was involved in research activity about transfer factors of radionuclides from environment to animals products and prevention treatments [10].

Accident in a foundry in the province of Milan

Monitoring surface waters is important as this matrix can receive radioactive effluents from nuclear, medical or industrial plants as well as from accidental fusion of materials containing radioactive sources; it's possible to detect radionuclides in solution or associated to suspended particles, thus incorporated in sediments and in living species.
Furthermore, the results of the measurements concerning the Po river show the almost constant presence of I131, clearly connected to bio-medical activities as nuclear plants haven't operated since 1987.

Since 1989, surface water of the Po river has been collected quarterly at Pontelagoscuro (Fe) and at Piacenza, upriver of the Caorso plant (this sampling location belongs to the "local network"): the comparison of the results of the γ spectrometry analyses carried out on the component in solution of this matrix (fig.3) showed a clear increase of the value of Cs137 (about 28 times higher than the previous three-months period) during the sampling of May 1989 upstream from the Caorso plant, vs. a Cs134 contamination basically constant throughout the year and close to the detection limit (these data items are not shown in fig. 3).

Fig. 3 – Cs134 and Cs137 contamination in the Po river (solution)

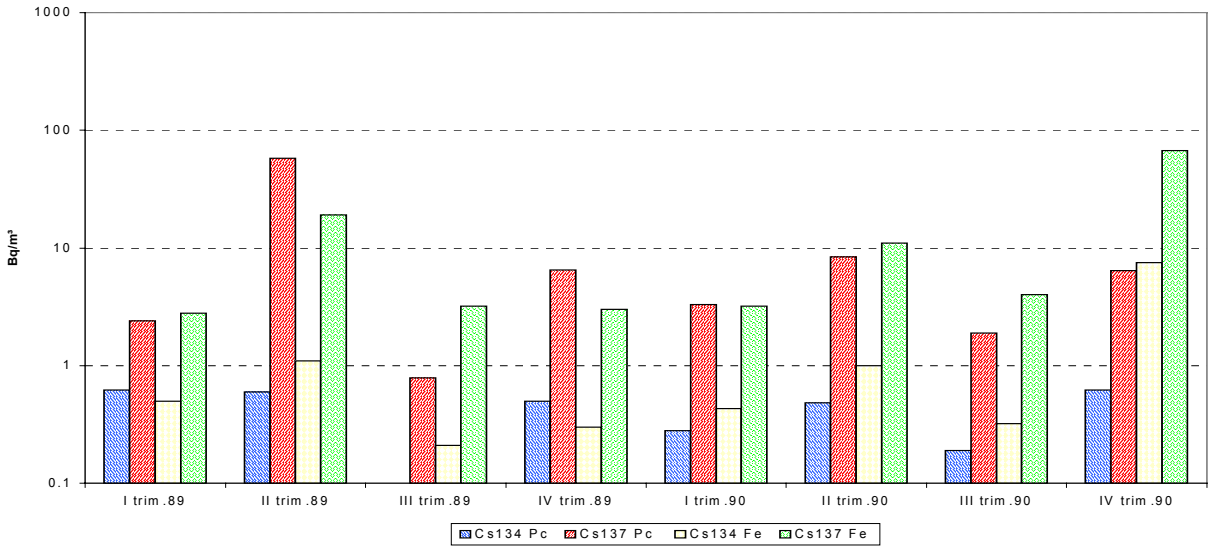


Such increase of contamination, which was not found at the Pontelagoscuro station, was clearly not to be correlated to the Chernobyl accident yet, but to an outlet of unknown nature into the Po river or into one of the tributaries upstream from the plant.

The analysis of the concentration values of Cs137 pointed out on May 1989 in suspended matter (fig. 4), compared with the data in solution, shows the higher associated of this radionuclide in the solution during the incident (Cs137/Cs134 ratio equal to 339 in

solution and 97 in suspended matter), while, “normally”, the chemical-physical characteristics of the radionuclides are such as to associate it rather to the particulate resulting from soil erosion, as the results of measurements carried out on samples collected at Pontelagoscuro in the last quarter of 1990, after a flood of the Po that had brought about a considerable amount of suspended sedimentable material, showed an increase of the values of Cs134 and Cs137.

Fig. 4 – Cs134 and Cs137 contamination in the Po river (suspended matter)



Later on, thanks to the collaboration of other regional labs, the cause of the 1989 polluting event was found to be the accidental fusion of a Cs137 source at a foundry of metal scraps in the province of Milan, which caused the contamination of the waters of the Lambro and then of the Po rivers.

This accident, besides pointing out the problem of metal scraps, also drew attention to the need to improve the control over the Po waters, since the quarterly sampling doesn’t allow a time representation of the incidents which may occur nor an estimate of the extent of the outlet.

It has therefore been considered to be quite necessary to control the waters continuously, possibly with more stations along the course of the river.

Since 1997, the Sezione ARPA of Piacenza has been able to analyse weekly samples continuously collected (nearly 1000 litres per week) at the centrifugation plant of the Po waters owned by ENEL-CRAM (MI), installed downstream from Caorso Plant and equipped with special treatment systems. The results of the measurements are given in the report about the local network of Caorso [(11)].

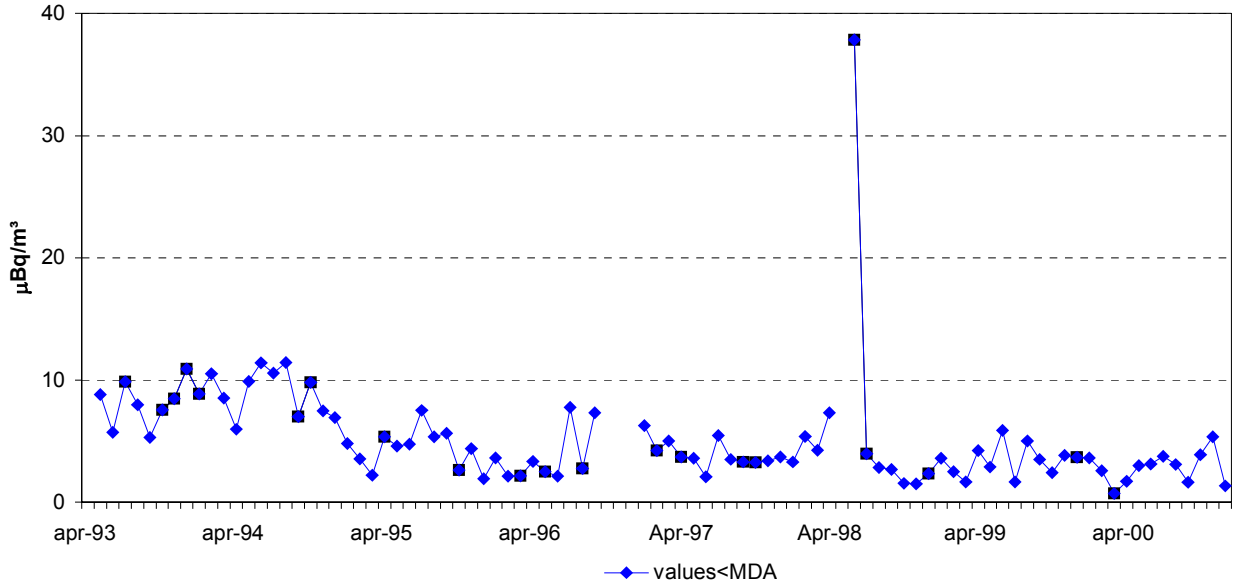
Such a monitoring system, unique in Italy in the field of environmental radioactivity, was, however, shut down in 2000.

Radiological accident in Algeciras (Spain)

At the beginning of June 1998, the regional laboratory of Milan pointed out an increase of Cs137 contamination in air up to 1-2 mBq/m³, nearly 100 times higher than levels normally measured in air. Official news, supplied by IAEA, gave information about an industrial accident occurred in a steel-plant located nearby Algeciras, in Spain, caused by an accidental fusion of a Cs137 source.

Such an increase was not measured by the continuously monitoring station of radioactivity in air in Piacenza, as it is set to point out emergency situation with higher contamination (detection limit nearly 1 mBq/m³); nevertheless, γ spectrometry analysis over the monthly packed filters of Air Force station at Monte Cimone (Mo) showed Cs137 values ten times higher than the other months (37.8 μBq/m³) (fig. 5).

Fig. 5 : Cs 137 contamination in air (atmospheric particulate)



At that time, when the cause of contamination was unknown, measurements of atmospheric particulate were increased, analysing the samples coming from the regional network of Air Quality Monitoring, in collaboration with the other provincial section of ARPA.

CONCLUSIONS

The monitoring activity carried out in the past twenty years by ARPA - Piacenza has allowed us to control the radioactive pollution over the region and to follow the evolution in time of incidental events on various environmental and food matrices, produced or marketed in our region.

At present, the contamination levels are close to or lower than the detection limits; also the control of import/export goods, requested by AUSL or Customs, points out that only

some mushroom samples show values higher than those which are provided for by the Community Rule 1661/99.

The activity of certifying goods for export has urged ARPA to get, in 1998, the SINAL accreditation in compliance with ISO 9001 and 45001 for the γ spectrometry measurements in foodstuff, Sr90 in milk and foodstuff, gross α and gross β in waters for human consumption.

The future revision of the monitoring network will have to take into account what is known about the contamination presently existing on the area, the evolution of the national network and the new emerging issues, such as those raised in the European Directive 83/98 about waters for human consumption.

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