ENVIRONMENTAL RADIOLOGICAL IMPACT OF NUCLEAR POWER. MONITORING AND CONTROL PROGRAMS

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INTRODUCTION

Radioactive contamination of the environment and public exposure to ionizing radiation may result from releases from programmed or accidental operations in regulated activities, or they may be due to preexisting situations such as contamination caused by past accidents, radioactive rain caused by nuclear tests, or increased natural radioactivity resulting from human activities. In many cases, both the emission sources and the environment should be monitored to determine the risk to the population and verify to what extent the limits and conditions established by competent authorities are being observed. Monitoring can be divided into three categories: monitoring of the emission source, of the receiving medium and of members of the public; individual monitoring of the population is extremely rare and would only be considered when estimated doses substantially exceed the annual public dose limit.

In practices likely to produce significant radioactive releases, as is the case of nuclear fuel cycle facilities, the limits and conditions for monitoring and controlling them and the requirements for environmental radiological monitoring are established in the licensing process. Programs implemented during normal operation of the facilities form the basis for monitoring in the event of accidents. In addition to environmental radiological monitoring associated with facilities, different countries have monitoring programs outside the facilities' zones of influence, in order to ascertain the nationwide radiological fund and determine possible increases in this fund.

In Spain, the facilities that generate radioactive waste have effluent storage, treatment and removal systems and radiological monitoring programs based on site and discharge characteristics. The environmental radiological monitoring system is composed of the network implemented by the owners in the nuclear fuel cycle facilities' zones of influence, and by nationwide monitoring networks managed by the Consejo de Seguridad Nuclear (CSN): Automatic Station Network (REA) and Sampling Station Network (REM).

The CSN's biannual reports to Spain's Congress and Senate provide information on the results of the monitoring programs, and a summary of the results is posted on the Consejo's Web site to provide information to the public. The data are also sent on a yearly basis to the European Union Commission and are published together with information from other member states.

NUCLEOELECTRIC ENERGY PRODUCTION AND ITS RADIOLOGICAL IMPACT

The operation of fuel cycle facilities results in generation of radioactive wastes that, when treated, yield solid waste and liquid and gaseous effluents; the former, after proper processing, are stored in installations suited to their characteristics, whereas liquids and gases are discharged to the environment once their contamination levels are suitably reduced.

Figure I shows a summary of the locations and main features of the Spanish fuel cycle facilities.

IN OPERATION

NPP	TYPE (Mwe)	START-UP
JOSÉ CABRERA	W-PWR (160)	1968
GAROÑA	GE-BWR (460)	1970
ALMARAZ I & II	W-PWR(973/982)	1980/83
ASCÓ I & II	W-PWR(973/966)	1982/85
COFRENTES	GE-BWR(1025)	1984
VANDELLÓS II	W-PWR(1009)	1987
TRILLO	KWU-PWR(1066)	1987

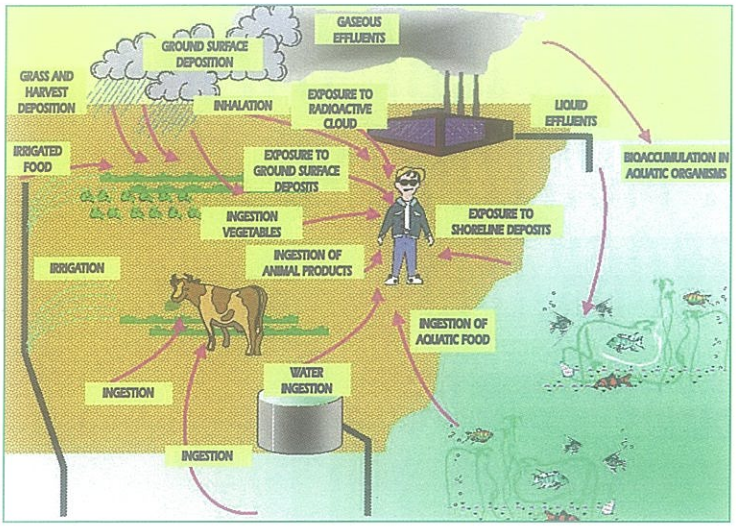
INSTALLATION	TYPE	START-UP
JUZBADO	Fuel fabrication plant	1985
EL CABRIL	Low radwaste repository	1992
QUERCUS	Uranium milling plant	1993

DISMANTLING/DECOMMISSIONIG

INSTALLATION	TYPE	START-UP
CN VANDELLÓS I	MAGNOX-GCR	1972
LA HABA	Uranium milling plant	1977
FUA	Uranium milling plant	1959

F1 *Nuclear Fuel Cycle Installations in Spain*

Public protection monitoring is based on an evaluation of the doses that could be received by an individual making use of the facilities' environs, and this evaluation should account for the risk involved in the activities being carried out (1). On estimating the doses that the population is liable to receive, a direct dosimetric control



F2.- *Liquid and gaseous effluents exposure pathways.*

TABLE 1. DISCHARGE LIMITS	LIMITS	EFFLUENT	VARIABLE	LIMIT
NUCLEAR POWER PLANTS	Instantaneous limits	Gaseous	Dose rate	5 mSv/a
		Liquids	Concentration	RPSRI (5 mSv/y)[1]
	Operational Restrictions	Total	Equivalent Effective Dose	0,1 mSv/y
		Gaseous	Equivalent Effective Dose	0,08 mSv/y[2]
		Liquids	Equivalent Effective Dose	0.02 mSv/y[2]
JUZBADO	Annual limits	Gaseous	Gross alpha activity	0,19 GBq/y
		Liquids	Gross alpha activity	12,03 GBq/y
	Instantaneous limits	Liquids	Maximum gross alpha Activity concentration	0,22 MBq/m^3
QUERCUS	Increase over river background levels	Liquids	Ra-226 Activity concentration	3,75 Bq/m^3
	Annual limits	Liquids	Ra-226 Annual activity	1,64 GBq/y
	Annual limits	Gaseous	Mineral dust concentration	15 mg/m^3
	Annual limits	Gaseous	Average yellow cake dust concentration	5 mg/m^3
	Dose limits	Total	Equivalents effective dose	0,3 mSv/y
CABRIL	Dose limits	Gaseous[3]	Equivalents effective dose	0,01 mSv/y

(1) Activity Concentration values derived from the dose limits for the protection of the public established in the Regulation on Sanitary Protection against Ionizing Radiations (RSPIR)
(2) Generic values, the distribution between liquids and gases is plant specific
(3) Zero release for liquid effluents

of all members of the public, as is done for professionally exposed workers, is obviously not feasible. In order to quantify the radiological impact, estimates must therefore be made on the basis of models that describe how radioactive contaminants are transferred to the different elements of ecosystems, considering an additional set of assumptions regarding the habits of individuals in different groups of population (2). Environmental radiological monitoring programs are used to verify that the physical-mathematical models suitably reflect the actual behavior of released effluents and that uncontrolled releases do not occur.

The issues concerning effluents and environmental radiological monitoring are included in the Technical Operating Specifications (ETF), official documents included in the operating permits of fuel cycle facilities. Based on a homogenization process carried out by the CSN, the EFT of most of these facilities contain the Radioactive Effluent Control Program (PROCER) and the Environmental Radiological Monitoring Program (PVRA); these programs are developed in the Calculation Manual for Exterior Dose (MCDE), which also contains a description of the main discharge channels, radiation monitoring instrumentation, and the methodology and parameters used to estimate doses to the population due to radioactive liquid and gaseous effluents (3).

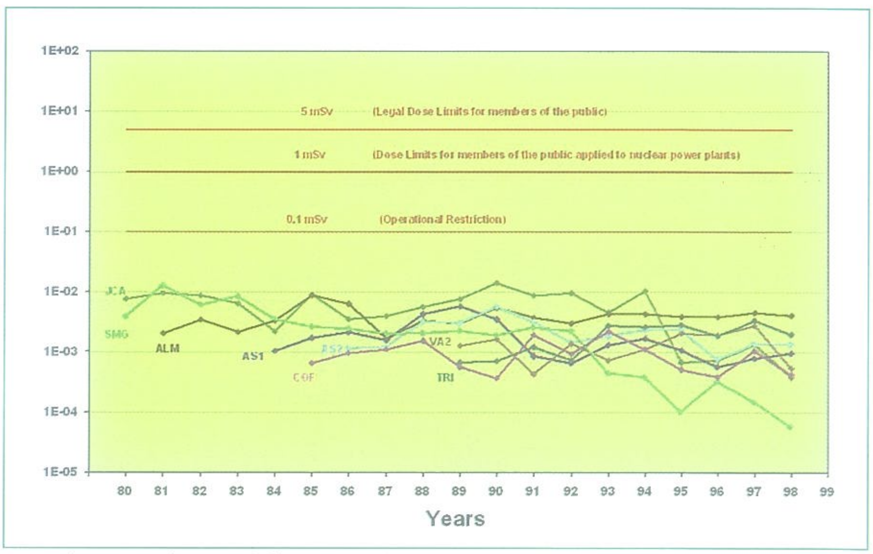
Monitoring and Control of Radioactive Effluents

Spanish legislation requires that facilities that may generate radioactive wastes be provided with adequate treatment and removal systems, in order to ensure that doses caused by discharges are lower than the limits established in the administrative licenses and that they are maintained at the lowest possible values.

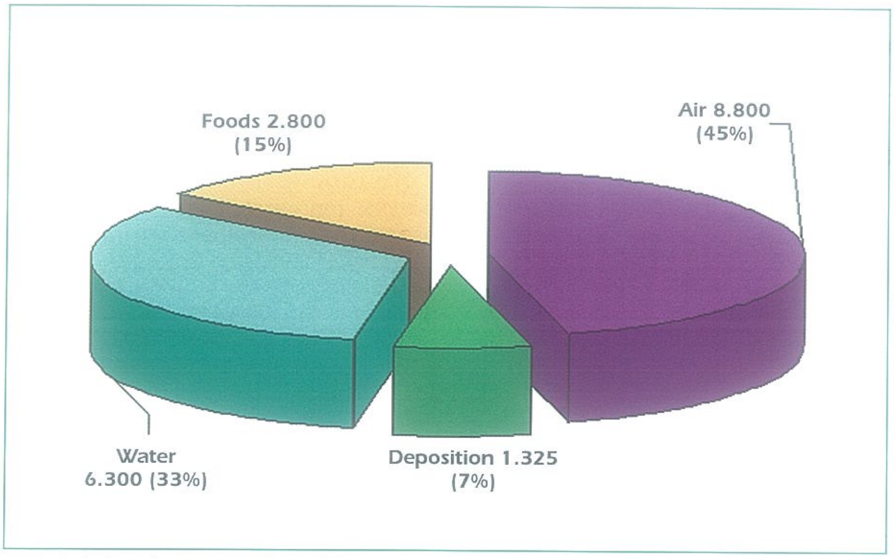
The CSN has defined the scope of effluent control programs (4) in accordance with international practices (5, 6); these programs contain the following:

- discharge limits,
- sampling and analysis programs, and doses calculations required to verify compliance with these limits,
- operating conditions of treatment systems, and
- requirements imposed on instrumentation for continuous monitoring of liquid and gaseous effluents.

In nuclear power plants, according to the model established by the CSN and implemented in the early 90's, the PROCER is defined in the ETF and is developed in the MCDE. The rest of the



F3. *Nuclear Power Plants. Total effective equivalent dose (mSv/y).*



F4. *Radiological environmental surveillance programmes analysis per exposure pathway.*

facilities have similar programs established that are included in different documents according to the facility. Table 1 contains a summary of the facilities' discharge limits, and Table 2 a summary of nuclear power plant sampling and analysis programs.

The facilities' owners provide the CSN with data on liquid and gaseous discharges and the estimated doses resulting from these releases; these data are included in the periodic operating reports and on magnetic support for loading into the Consejo's liquid and gaseous effluent database (ELGA). The CSN evaluates these data, verifies compliance with established limits and conditions, and tracks discharge trends in order to detect operational incidents and verify that treatment systems are operative. For this purpose, some internal reference values have been defined based on the facilities' operating experience; if these values are exceeded, information is requested from the facility on the possible activities that could have caused the increased effluents. Regulatory control of discharges is also supplemented by the effluent inspections that the CSN periodically performs at these facilities.

The facilities' releases are generally kept at values below the CSN's internal reference levels and are comparable to the values of other European and American facilities, as shown in Table 3, which indicates the releases of pressurized water and boiling water reactors by unit of electric energy generated.

The doses owing to radioactive discharges from facilities are calculated to verify compliance with established limits, and always using very conservative criteria and values. The methodology and assumptions used are common to all types of facility, except for some site-specific parameters. Figure II shows a diagram of the main channels through which liquid and gaseous effluents are transferred. The values obtained are much lower than public dose limits and represent a small fraction of discharge limits, as shown in Figure III for nuclear power plants.

TABLE 2. RADIOACTIVE EFFLUENTS SAMPLING AND ANALYSIS PROGRAMMES IN NUCLEAR POWER PLANTS

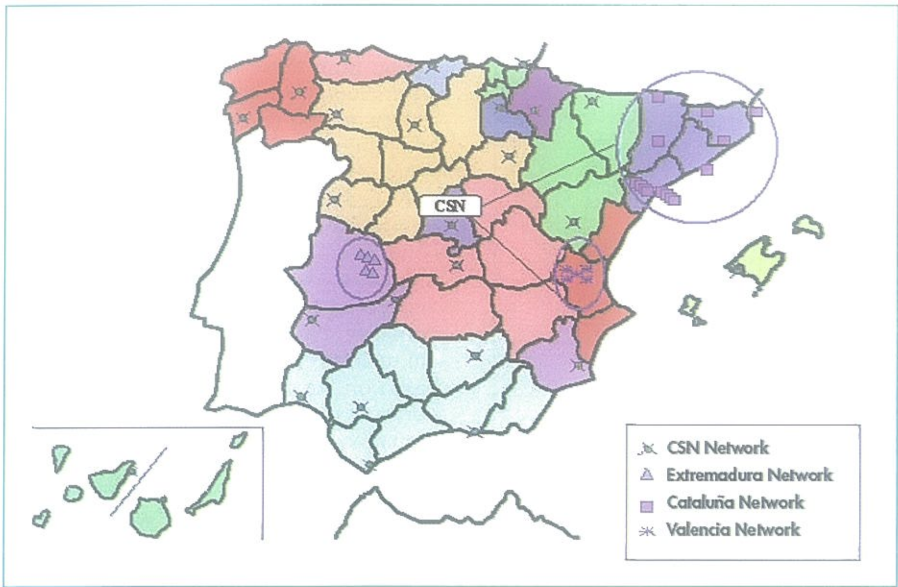
TYPE OF RELEASE	SAMPLING FREQUENCY	MINIMUN ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS
LIQUID EFFLUENTS			
Batch releases	Each batch	Each batch	Gamma emitters
			I-131
	One batch monthly	Monthly	Gamma emitters (Dissolved Gases)
	Each batch	Monthly composite	H-3
			Gross alpha
	Each batch	Quarterly composite	Sr-89/90
Continuous releases	Continuous	Weekly composite	Gamma emitters
			I-131
	Monthly Grab sample	Monthly	Gamma emitters (Dissolved Gases)
	Continuous	Monthly composite	H-3
			Gross alpha
	Continuous	Quarterly composite	Sr-89/90
GASEOUS EFFLUENTS			
Continuous releases and containment purge	Monthly Grab samplel	Monthly	Gamma emitters
			H-3
	Continuous sampling	Weekly (Charcoal sample)	I-131
	Continuous sampling	Weekly (Particulate sample)	Gamma emitters
	Continuous sampling	Monthly composite (Particulate sample)	Gross alpha
	Continuous sampling	Quarterly composite (Particulate sample)	Sr-89/90
Off-gas (BWR)/ gas tanks	Grab samplel	Monthly/Each tank	Gamma emitters
	Continuous sampling	Weekly (Charcoal sample)	I-131
	Continuous sampling	Weekly (Particulate sample)	Gamma emitters
	Continuous sampling	Monthly composite (Particulate sample)	Gross alpha
	Continuous sampling	Quarterly composite (Particulate sample)	Sr-89/90

Environmental Radiological Monitoring Around Facilities

Environmental radiological monitoring in the vicinity of nuclear and radioactive facilities of the nuclear fuel cycle began to be implemented at the beginning of the Spanish nuclear program, in the late 60's, and it has been developed according to the different lifetime stages of these facilities, in the preoperational, operational, and dismantling and decommissioning phases.

Therefore, there are currently three different kinds of environmental radiological monitoring programs depending on the type of facility and its operating state:

- those developed on the seven sites of the nine operating nuclear power plants.



F5. *Radiological environmental surveillance on line monitoring network.*

TABLE 3. NORMALIZED RADIOACTIVE DISCHARGES (GBq/GWh)* NPP						
GASEOUS EFFLUENTS						
COMPONENTS	SPAIN		EUROPEAN UNION		USA	
	PWR	BWR	PWR	BWR	PWR	BWR
Noble Gases	1.95E+01	3,63E+01	6,50E-+00	6,21E+01	2,13E-+01	1,67E+02
I-131	3,14E-05	8,06E-05	3,36E-05	3,13E-04	1,21E-04	7,95E-04
Aerosols	3,46E-05	9,75E-05	5,77E-05	3,52E-02	4,73E-04	1,89E-03
Tritium	1,99E-01	7,36E-02	2,91E-02	5,33E-02	5,47E-01	3,52E-01
LIQUID EFFLUENTS						
COMPONENTS	SPAIN		EUROPEAN UNION		USA	
	PWR	BWR	PWR	BWR	PWR	BWR
Total activity excep tritium	5,34E-03	1,94E-03	5,27E-03	5,36E-03	9,90E-03	9,46E-03
Tritio	3,01E+00	5,58E-02	3.56E-00	2,77E--01	3,27E-00	1,16E-01

(*) 1980-1997 Average values

TABLE 4. RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMMES NUCLEAR POWER PLANTS	
TYPE OF SAMPLE	**ANALYSIS**
AIR	Gross beta, Sr-90, Gamma Spectrometry, I-131
POTABLE WATER	Gross beta, Residual beta, Sr-90, Tritium, Gamma Spectrometry
RAIN WATER	Sr-90, Gamma Spectrometry
GROUND AND SURFACE WATER	Gross beta, Residual beta, Sr-90, Tritium, Gamma Spectrometry
SOILS, SEDIMENTS AND BIOTA	Sr-90, Gamma Spectrometry
MILK AND CROPS	Sr-90, Gamma Spectrometry, I-131
MEAT, EGGS, FISH, SEAFOOD AND HONEY	Gamma Spectrometry

ting nuclear fuel cycle facilities: Quercus plant, Juzbado factory and El Cabril facility.

- those implemented in facilities in phase: Vandellós I Nuclear Power Plant, uranium concentrate factories in Andujar (FUA) and La Haba (Lobo-G).

The monitoring programs developed in these cases are similar in design to those in effect during the operating phase of the respective facilities, although their scope is modified to account for their status.

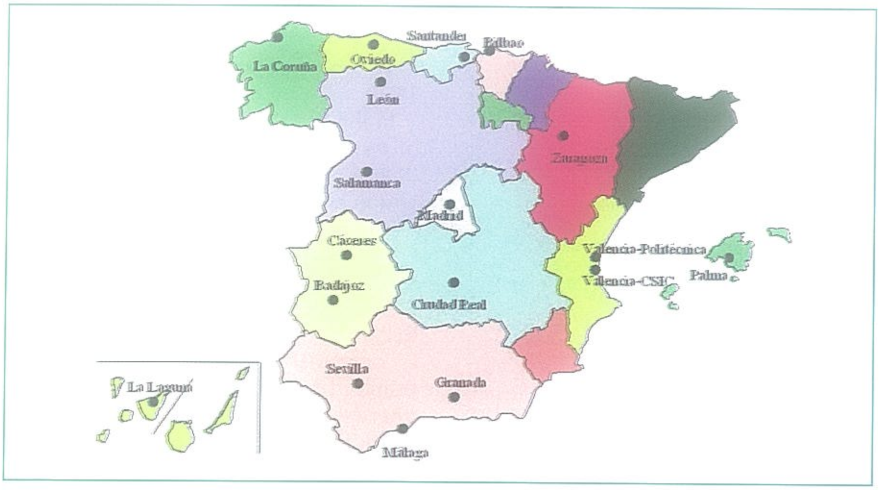
The basic goals of the PVRA are to provide representative measurements of radioactivity in the most important potential channels of exposure of people on each site and to verify the effectiveness of the effluent monitoring programs and environmental radionuclide transfer models. The PVRA address three different aspects:

- The sampling, analysis and measurement programs of radiation levels and radionuclides present in the environment within a 30 Km. radius.
- The census of land and water use, which is used to identify any changes that occur and to verify that the required modifications are made in the program accordingly.
- The analytic quality control program of the environmental monitoring established, with a range between 5% and 15% of samples and analyses.

Spanish power plant PVRAs are originally designed on the basis of NRC Regulatory Guide 4.8 (7) and JEN Guidelines 3 (8) and 9 (9). In 1993, the CSN published Nuclear Safety Guideline 4.1 (10) on PVRA design and development for nuclear power plants. Current programs are based on this Guideline and are developed in detail in each facility's MCDE, which also defines reporting levels for activity concentrations in environmental samples, established by the Consejo on the basis of effluent limitations; if these levels are exceeded, the facility must report to the CSN and undertake a study to determine a possible relationship with the plant's discharges. In other fuel cycle facilities, the PVRAs were defined in accordance with specific standards and guidelines (11, 12).

The number and location of sampling points, the type of samples to be collected and the required analyses are defined in the preoperational phase; this phase, which lasts a minimum of two years, is intended to radiologically characterize the site before it is affected by the facility's discharges. The main channels of human exposure to radiation are monitored, as well as other ecosystem elements that are good indicators of radioactivity evolution in the environment.

Tables 4 details the analyses required for each type of sample in a nuclear power plant PVRA, and Table 5 summarizes the programs of the remaining fuel cycle facilities. Around 20,000 analyses are performed every year, as



F6. *CSN Air and Soil Samplig Stations Network.*

shown by the graphic in Figure IV, which represents the analyses made during 1997 in the different monitored channels in these facilities.

Every year the facilities send the results of the monitoring programs and corresponding quality controls to the CSN, and every three years send the new census on land and water usage. The PVRA data are stored in the CSN's environmental radioactivity measurement database (KEEPER), together with data obtained from nationwide radiological monitoring programs. The Consejo evaluates these results, considering the data obtained during the preoperational phase and the values from previous years, and analyzes their evolution during the facility's operational period. The results of the quality control program are also examined in relation to the PVRA data.

The Consejo carries out an independent control of the facilities' PVRAs by means of its own monitoring programs; the sampling points, types of samples and analyses made coincide with those made by the owners. For the Vandellós-I and -II, Ascó and Cofrentes power plants, this monitoring has been entrusted to the Autonomous Regions of Catalonia and Valencia, respectively. In the rest of the facilities, the CSN has traditionally relied on CIEMAT's technical support to perform the analyses. In 1999, the Consejo reached agreements with the REM laboratories located in the Autonomous Regions where the rest of the facilities are located to perform this independent monitoring, the scope of which has been established at 5% of PVRA samples and analyses. The CSN also performs periodic inspections and audits of these programs. On the other hand, the EU Commission can visit the facilities for purposes of verification, in accordance with article 35* of the Euratom Treaty. The first of these verifications was carried out in Vandellós II with very satisfactory results.

ENVIRONMENTAL RADIOLOGICAL MONITORING NOT ASSOCIATED WITH FACILITIES

In 1985, in view of Spain's imminent membership in the European Union and the number of nuclear facilities in the country, it became obvious that the CSN had to establish a nationwide radiological monitoring network; this need was heightened by the Chernobyl accident. According to the original project, the national monitoring network would be independent from the network associated with nuclear facilities, would include all Autonomous Regions, and would account for features such as coastal limits and extension when establishing the number and characteristics of the sampling points. The purposes of the monitoring network, which has been operative since 1992, are as follows:

- Ascertain the distribution and evolution of radioisotopes present in the environment and the levels of environmental radiation, and provide an environmental database to be able to obtain reference levels at any time.
- Provide experimental data for estimating the potential radiological impact on the population as a result of possible radioactive contamination of the environment.
- Report to the Congress, Senate and public opinion on the radiological quality of the environment in Spain.
- Suitably enforce the requirements of articles 35 and 36** of the Euratom treaty.

In order to achieve these goals, an Automatic Station Network (REA) for real-time measurements of atmospheric radioactivity and a Sampling Station Network (REM) for sampling and analysis programs of the atmosphere, ground, rivers and coasts were implemented.

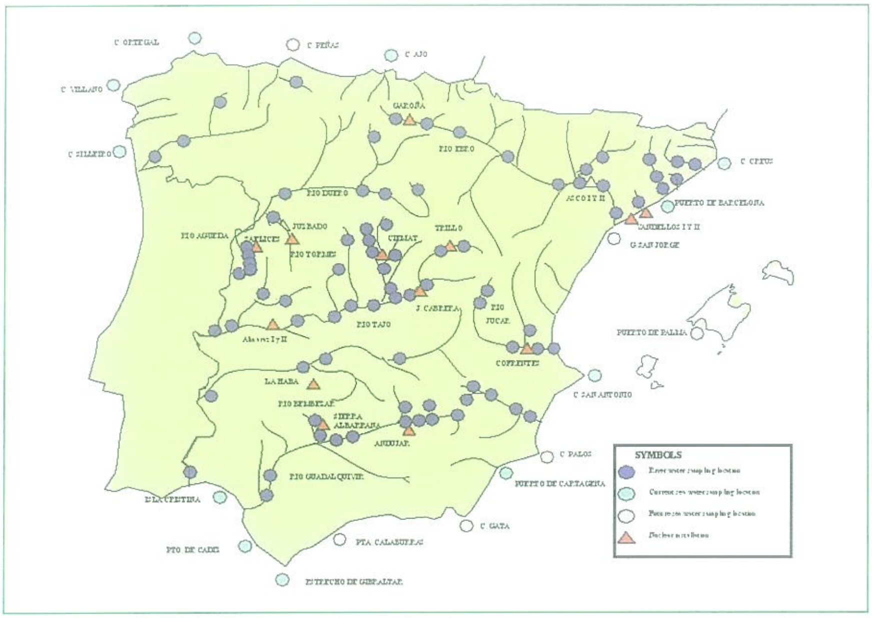
Automatic Station Network (REA)

The purpose of establishing the Automatic Station Network is to perform real-time monitoring of atmospheric radioactivity in different zones around the country: Most of the CNS-managed network stations are located in measurement stations of the National Meteorology Institute and are connected through the switched telephone network to a supervision and control center located in CSN headquarters. Table 6 shows the variables monitored by the automatic stations.

There are also other air monitoring networks not operated by the CSN, such as the networks of the Autonomous Regions of Catalonia, Valencia and Extremadura. The Valencia and Catalonia stations are connected to the CSN, which also receives data from a Portuguese station (Penhas Douradas). The map in Figure V shows the location of these stations. The General Directorship of Civil Defense also has a Radioactivity Warning Network (RAR) composed of 900 radiation rate measurement points.

The Network has achieved a high level of availability. At times data are lost due to circumstances that in most cases are not attributable to the Network proper. The results of the measurements taken in the different stations provide characteristic values of the environmental radiological fund. The CSN's Web site provides information on the daily average value and the average dose rate value for the previous thirty days at each REA station, as well as an historical file of the same data so that longer time periods can be consulted.

** " Each Associate State will create the necessary installations in order to control permanently the radioctivity index in the atmosphere, in the waters and in the soil, as well the observance of the basic norms. The Commission will have right to accede to the control installations and will be able to verify its fulfillment and afficacy".*
*** " The information related to the mentioned controls in the 35th article will be communicated regulary by the competent authorities to the Commission in order to be informed about the radioctivity index that would affect to the population".*



F7. *CSN Coastal and Inland waters Sampling Stations Network.*

TABLE 5. RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMMES FUEL CYCLES INSTALLATIONS	
TYPE OF SAMPLE	**ANALYSIS**
AIR	Gross alpha, U-nat, Th-230, Pb-210. Rn-222, Gamma dose rate
POTABLE WATER	Gross alpha, U-nat, Ra-226, Th-230, Pb-210
GROUND AND SURFACE WATER	Gross alpha, Gross beta, Residual beta, U-nat, Ra-226, Th-230, Pb-210
SOILS	Gross alpha, U-nat, Ra-226, Th-230, Pb-210
SEDIMENTS, TERRESTIAL AND AQUATIC BIOTA	Gross alpha, Gross beta, Residual beta, U-nat., Ra-226, Th-230
MILK, MEAT AND CROPS	Gross alpha, U-nat, Ra-226, Th-230, Pb-210

TABLA 6. ON LINE MONITORING NETWORK	
RADIOLOGICAL DATA	**METEOROLOGICAL DATA**
Gross alpha activity	Wind velocity
Gross beta activity	Wind direction
I-131	Standard Deviation of Wind direction
Rn-222	Lapse rate temperature
Direct gamma radiation	Relative humidity
	Rain intensity
	Solar radiation

Sampling Station Network (REM)

The sampling station network includes monitoring programs for the aquatic medium, including both continental and coastal waters, the atmosphere and the ground. To execute these programs, the CSN has entered into specific collaboration agreements with the Experimentation Center (CEDEX) of the Ministry of Public Works, which has been carrying out a radiological monitoring of Spain's major rivers since 1978, and with 18 laboratories in different Universities (Table 7), which conduct the sampling programs on university campuses. CEDEX conducts a program for monitoring the rivers of the major Spanish hydrographic basins with more than 80 sampling points, and also provides the CSN with the results of radiological controls of drinking water in different areas around the country. Figures VI and VII show the location of the sampling points, and Tables 8 and 9 summarize the programs currently underway.

The European Union's member states have tried to reach a consensus regarding the scope of nationwide monitoring programs within the framework of articles 35 and 36 of the Euratom Treaty. However, because different practices were followed, the Commission was requested to develop a recommendation regarding minimum prerequisites for enforcing these articles. The recommendation was drafted by the group of experts of articles 35 and 36, to which CSN technicians belong, and publication is due for mid-1999.

In the last few years, implementation of two monitoring networks has gradually been consolidated in European Union countries:

- A *Dense Network* with numerous sampling points and in which the lowest required detection levels are relatively high. The Spanish dense network is currently composed of 28 REA points, 18 air sampling points, some 85 interior surface water points, 11 seawater points along the coastal perimeter, and 23 drinking water points. Adapting to the Commission's requirement will require analyses of the so-called typical diet and milk samples.
- A *Spaced Network* is composed of very few sampling points and the required lower levels of detection are very low so that values above these levels are always obtained, in order to be able to track the evolution of activity concentrations over time. The spaced network is still not implemented in Spain, except for the CIEMET's high-flow air sampling station and some other sampling points that meet the requirements of this network. This network is currently in the design phase and it is estimated that it will contain five points, accounting for the country's surface area.

The CSN has carried out a study of the necessary requirements for adapting nationwide monitoring to the Commission's Recommendation, with a view to fully implementing it in the near future.

QUALITY ASSURANCE AND CONTROL PROGRAMS. PROCEDURAL STANDARDIZATION

Measuring radioactivity in environmental samples involves a lengthy process that includes everything from collection and preparation of representative samples and their chemical analysis to calibration of measurement equipment. Evaluating the reliability of final results is not a simple matter, as the different process stages must be considered. The quality of the results obtained in environmental radiological monitoring programs has been a constant concern of the CSN and the facilities; in 1987 the CSN developed a document on quality assurance in these programs, which was discussed in 1989 in a meeting with 12 low-activity measurement laboratories.

In nuclear facilities, where quality systems have been applied since the

TABLE 7. LABORATORIES IMPLEMENTING CSN SURVEILLANCE PROGRAMMES

Regions	Laboratory
EXTREMADURA	U. EXTREMADURA (Badajoz). Cátedra de Física Atómica, Molecular y Nuclear
	U. EXTREMADURA (Cáceres). Laboratorio de Radiactividad Ambiental. Departamento de Física
BALEARES	U. ISLAS.BALEARES Dpto. de Física (Física Atómica, Molecular y Nuclear) y Departamento de Química
CANTABRIA	U. CANTABRIA. Laboratorio de Radiactividad Ambiental. Cátedra de Física Médica. Departamento de Ciencias Médicas y Quirúrgicas
ANDALUCIA	U. GRANADA. Laboratorio de Radioquímica y Radiología Ambiental. Departamento de Química Inorgánica. Facultad de Ciencias
	U. MALAGA Laboratorio de Radiactividad Ambiental. Departamento de Física Aplicada. Facultad de Ciencias
	U. SEVILLA. Departamento de Física Atómica, Molecular y Nuclear. Facultad de Físicas
CASTILLA LEÓN	U. LEÓN. Laboratorio de Radiactividad Ambiental. Departamento de Física, Química y Expresión Gráfica. Facultad de Biológicas
	U. SALAMANCA. Laboratorio de Radiactividad Ambiental. Cátedra de Física Nuclear. Facultad de Física
CANARIAS	U. LA LAGUNA. (Tenerife). Departamento de Medicina Física y Farmacología. Cátedra de Física Médica. Facultad de Medicina
MADRID	U. POLITÉCNICA. Laboratorio de Ingeniería Nuclear. Departamento de Hidráulica y Energética. E. T. S. I. Caminos, Canales y Puertos
PAÍS VASCO	U. PAÍS VASCO. Departamento de Ingeniería Nuclear y Mecánica de Fluidos. E. T. S. Ingenieros Industriales y de Telecomunicación
VALENCIA	U. DE VALENCIA. Edif. Investigación. Laboratorio de Radiactividad Ambiental
	U. POLITÉCNICA. Laboratorio de Radiactividad Ambiental. Servicio de Radiaciones. Dpto. de Ingeniería Química y Nuclear
CASTILLA LA MANCHA*	U. CASTILLA LA MANCHA (CIUDAD REAL). Centro de Instrumentación Científica, Análisis y Tecnología
GALICIA*	U. LA CORUÑA. (Ferrol) Departamento de Química Analítica. Escuela Universitaria Politécnica
ASTURIAS*	U. ASTURIAS. (Oviedo) Laboratorio de Energía Nuclear. E. T. S. Ingenieros de Minas
ARAGÓN*	U. ZARAGOZA. Cátedra de Física Atómica, Molecular y Nuclear. Facultad de Ciencias

* Since 1997

design phase, radioactivity measurements are integrated into their quality programs. As regards technical aspects, the MCDE includes a list of all applicable procedures for suitably developing effluent control and environmental radiological monitoring programs; as indicated above, the latter, require that the owners apply an analytical quality control with a range of 15 to 15% of samples. Some basic elements of quality systems were established in the REM from the time it was implemented; thus, in the collaboration agreements between the CSN and Universities, it was required that a technical document be developed, prior to incorporation into this network, that included the following aspects:

- a description of sampling, detection and measurement equipment
- sampling, analysis and measurement procedures used by the laboratory
- a quality assurance program for the measurements made
- participation in analytical inter-comparison exercises organized by the CSN.

Application of quality systems that fully integrate the organization's structure, responsibilities, procedures, processes and resources required for suitably managing quality is an effective way to achieve the required goals. For this purpose, the Consejo in 1997 requested that participants in the REM develop Quality Manuals and a program for establishing, implementing and optimizing it.

In order to verify that the established quality assurance programs are properly enforced, internal controls are introduced into the organizations proper and external actions are taken, such as comparative inter-laboratory studies and audits. Since 1992, the CSN has been undertaking annual analytical inter-comparison campaigns using samples similar to those analyzed in the environmental radiological monitoring programs in collaboration with CIEMAT, which had been independently carrying out these campaigns since 1985. Recently, work has begun in collaboration with the IAEA, which provides the samples to be analyzed and uses the results of some Spanish campaigns in its inter-laboratory studies. Some 30 national laboratories that make environmental radioactivity measurements take part in the CSN's inter-comparison exercises, and they were joined in 1997 by a laboratory of Portugal's General Directorship for the Environment.

Spanish laboratories also take part in European exercises, within the framework of articles 35 and 36 of the Euratom treaty, and in other international campaigns. The IAEA is currently beginning an exercise for evaluating analytical methods used to determine Sr-90, in which a large number of Spanish laboratories are involved in coordination with the CSN and CIEMAT.

Inter-comparison campaigns have proved to be an effective way for improving the reliability of data obtained in environmental radiological monitoring programs through the implementation of lessons learned in the different exercises, the results of which are analyzed and discussed in periodic meetings between the CSN and the laboratories.

In this context, Technical Meetings on "Quality in the Control of Environmental Radioactivity", organized by the Industrial Engineering and Telecommunications Engineering Schools of the Basque University and sponsored by the Spanish Nuclear Society, were held in September 1998 in Bilbao with the participation of representatives from nuclear facilities, environmental radioactivity measurement laboratories, AENOR, ENAC, IAEA, European Union, CIEMAT and CSN. During these meetings, the difficulties involved in measuring environmental radioactivity were discussed in depth and the most important problems were analyzed, in order to find solutions that ultimately contribute to achieving greater reliability in monitoring program results. The most problematic aspects identified were issues

TABLE 8. CSN NATIONAL ENVIRONMENTAL SURVEILLANCE PROGRAMMES			
TIPE OF SAMPLE	SAMPLING FREQUENCY	TYPE OF ANALYSIS	FREQUENCY OF ANALYSIS
AIRBORNE PARTICULATE	Continuous Weekly sample	Gross alpha, Gross beta Sr-90, Gamma Spectrometry	Weekly Quarterly composite
AIRBORNE IODINE	Continuous Weekly sample	I-131	Weekly
RAIN WATER DRY DEPOSIT (*)	Continuous	Gross Beta, Sr-90 Gamma spectrometry	Weekly Quarterly composite
SOIL	Annual	Gross Beta, Sr-90 Gamma spectrometry	Annual

(*) Deposit collected in the absence of rain.

related to preparing radioactive standards, calculating uncertainties and drafting applicable regulations, and it was agreed that work groups would be set up in each of these areas. It was also recommended that these groups carry out their activities in coordination with AENOR.

During the annual meeting of the CSN and the laboratories held last October, the three work groups – STANDARDS, UNCERTAINTIES and REGULATIONS – were formally set up, and a coordinator was named for each group. These groups have begun working and have held coordination meetings: in the Regulations Group, three working subgroups have been set up to develop procedures for the main stages of the environmental sample radioactivity measurement process: sampling, sample preservation and preparation, analytical methods, and measurement equipment. On the basis of issues considered to be high priority, specific groups have been created to develop soil and water sampling procedures, analytical procedures for Sr-90 in soil and for total beta activity and beta balance in water, and procedures for calibrating gamma spectrometry equipment. These groups will be integrated into the Subcommittee for Safety, Radiological Protection and the Environment (SC-03) of AENOR's Technical Standardization Committee.

CONCLUSIONS

The following is deduced from the results of the effluent control and monitoring programs in Spanish nuclear fuel cycle facilities and the environmental radiological monitoring programs both in their zones of influence and nationwide:

• Radioactive releases are comparable to those from similar European and American facilities; the doses from these releases, conservatively estimated, are much lower than public dose limits and represent a small fraction of effluent limitation.

• In the PVRAs, the channels of transfer with the greatest incidence on potential doses to the population do not show a significant increase over the radiological fund; in accumulative channels of transfer, the increases to be expected owing to their characteristics occur.

• Measurements taken in different REA stations show values characteristic of the environmental radiological fund.

• In the REM:

- Analyses of airborne and deposition samples generally show homogeneous values consistent with radioactive fund levels.

- In rivers, total alpha and beta activity concentrations reflect the ground characteristics, the incidence of organic discharges from cities, and the existence of crops, with isotopes being detected at times in fertilizers. No artificial gamma emitting isotopes have been detected in any of the monitored rivers. At times an increase in tritium concentrations downstream of nuclear power plants is observed.

- Coastal waters show results consistent with their high contents in salts, specifically in the total beta activity index.

• Implementation of Quality Manuals and development of standardized procedures, together with the inter-comparison exercises that the CSN carries out every year, are effective ways to ensure the adequate reliability of monitoring program results.

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