

# Environmental Radioactivity

Maria José Madruga

---

One of the main activities of the Environmental Radioactivity Group was to perform the Radiological Environmental Monitoring Programmes in collaboration with the Measurement Laboratories (LM), the Dosimetry and Radiobiology (GDR) and the Radiological Protection and Radioactive Waste Management (GRRR) Groups. These surveys were established according to Articles 35 and 36 of the EURATOM Treaty Recommendations and its execution legally attributed to ITN (Decree-Law 138/2005 of 17<sup>th</sup> August). To carry out these programmes a considerable effort of the Group has been made in terms of human resources (about 75% of the time consumed). This programme involved a financial cost of about 343 000 €.

Current research activities are ongoing to investigate the levels of radioactive contamination in the atmosphere (aerosols) aquatic and terrestrial environments. In January- February 2009, the Group participated in collaboration with other institutions, in the elaboration of seven research projects submitted to the FCT (Portuguese Foundation for Science and Technology) funding. Only one project was financed concerning the radioactivity in the atmosphere.

The Group participated in collaboration with the Measurement Laboratories in five international inter-comparison exercises: two concerning the determination of natural and artificial radionuclides in drinking water samples, organized by the IAEA/ALMERA and by the Laboratorio de Medidas de Baja Actividad, Universidad de País Vasco, Bilbao (Spain); two for the determination of alpha and gamma emitters in phosphogypsum organized by the IAEA/ALMERA and the CSN (Consejo de Seguridad Nuclear), Spain; and, one concerning the determination of gamma emitters in simulated filters organized by the IAEA/ALMERA. The results published in 2009 were in good agreement/compatible with the reference values.

Regarding the indoor radon measurements by solid state nuclear track detectors (SSNTD), some improvements were implemented during 2009, including new film supports, modifications to the

etching process and improvement of the measurements quality assurance.

During 2009, several interventions were carried out on the Radionuclide Particulate Station (RN53) at S. Miguel, Azores, including the substitution of some electronic components of the detection system and pump inverter. The testing phase was initiated at December and last for three weeks of continuous working. Due to a detector breakdown, the test was stopped and the detector was sent to Italy for repair. After return, the detector will be installed and a new testing phase will begin, aiming the certification of the station during 2010. This station will be part of the International Monitoring System, established in the framework of the CTBT (Comprehensive Nuclear Test Ban Treaty).

The technical services developed by the Group are carried out under contract with companies or, by request from enterprises or Government organizations. The technical services concern the evaluation of the radioactivity levels in public water supplies (Decree-Law n°306/2007) and mineral waters and indoor radon measurements. The group income of these technical services was about 35 000 €.

A great effort of the Group have been undertaken in order to submit the accreditation of three radioanalytical techniques to IPAC, which was carried out in October 2009. Some of the members Group elaborated the technical and management procedures following the ISO/IEC 17025 requirements and have also participated on the Technical and Management Working Groups.

Two researchers of the Group were involved on the working group to define the ICP-MS characteristics and have also participated as Jury membership of the tender to its acquisition.

Members of the Group were involved in several committees from EU (Group of Experts of Art. 35), IAEA, CTBT.

One of the tasks of the Group is the education and training of staff and young students. During this year two MSc theses and two DFA in “*Safety and Radiological Protection*” were concluded..

---

## Research Team

### Researchers

M. J. MADRUGA, Princ., Group Leader  
F. P. CARVALHO, Princ.  
M. J. REIS, Aux. (25%)  
J. A. CORISCO, Aux.

### Students

A. R. GOMES, FCT grant  
H. FONSECA, FCT grant  
J. MELO, FCT grant  
E. ANDRADE, (MSc, until October 2009)

### Technical Personnel

J. M. OLIVEIRA (70%)  
A. LIBÂNIO  
A. MOURATO

### Collaborators

I. LOPES  
M. M. MALTA

## Radiological Environmental Monitoring Programmes

M.J. Madruga, F.P. Carvalho, M. Reis, J.G. Alves, J.A. Corisco, R. Trindade, J.M. Oliveira, A. Libânio, A. Mourato, G. Silva, L. Portugal, I. Lopes, J. Abrantes, L. Silva, L. Torres, M. Malta, A.R. Gomes, G. Carvalhal, H. Fonseca, J. Melo, M. F. Pereira, A. Batista

### Objectives

The Article 35 of the EURATOM Treaty stipulates that “each Member State shall have the facilities necessary to carry out the continuous monitoring of the levels of radioactivity in the air, water and soil and to ensure the compliance with the Basic Safety Standards”. The Article 36 of the same Treaty stipulates that “the appropriate authorities shall periodically communicate information on the checks referred to in Article 35 to the Commission so that it is kept informed of the level of radioactivity to which the public is exposed”.

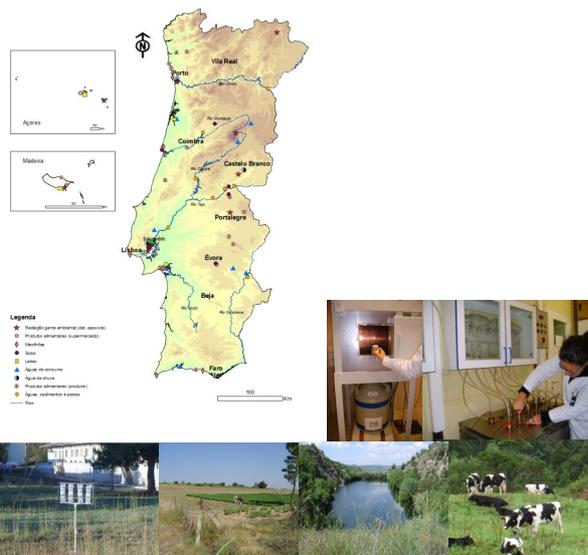
The Radiological Environmental Monitoring Programmes planned according to the Articles 35 of the EURATOM Treaty requirements include the Programme at a National Level, established by law in 2005 and the competency of its execution legally attributed to ITN (Decree-Law 138/2005, 17<sup>th</sup> August), the Source Related Programme for the ITN *Campus* and the Specific Programme for the Regions Around Old Uranium Mining Sites.

The main goals of the radiological environmental survey are to determine the artificial and natural radionuclide levels in environmental compartments (aquatic, terrestrial and atmospheric environments) considered as direct pathways of contamination to man and to evaluate the external radiation levels in order to provide information for the assessment of the potential exposure of the Portuguese population.

### Results

The monitoring programme at a national level concerns the radioactivity measurements of environmental and foodstuff samples collected along the country. The monitoring programme carried out for the ITN *campus* includes measurements of external radiation levels (gamma dose) and determination of radionuclide activity concentrations in relevant environmental samples (aerosols, rain water and soils) in order to check the operation conditions and discharge controls adequacy and to maintain a continuing record on environmental radionuclide levels related to the source. Monitoring of the regions around old uranium mining and milling sites was performed. Field missions were carried out in the counties of Guarda, Trancoso, Pinhel, Nelas, Mangualde and in the hydrographic basin of Mondego River, to collect water, soil, and vegetable samples for analysis in the laboratory. Radon measurements and aerosol samples were collected near the uranium mining waste dumps. Particular attention was paid to contamination of agriculture soil and irrigation water near uranium mining waste, and radionuclide soil-to-plant transfer. In mine pits that are now permanent ponds with aquatic fauna including fish, radionuclide accumulation by fish was investigated in order to assess the risk of radiation exposure to fish consumers. Radionuclide transfer to vegetation

spontaneously growing on sludge from acid and radioactive mine water treatment was investigated as well.



During 2009 about 650 samples (aerosols, rainwater, surface water, drinking water, sediments, fish, mixed diet, complete meals, milk, soils, etc.) were collected according to international sampling procedures and a total of about 2200 analyses were performed for the determination of artificial and natural radionuclides, using gamma and alpha spectrometry, alpha/beta measurements and liquid scintillation technique. Integrated measurements of the ambient dose equivalent with thermoluminescent dosimeters were also performed. The results show that the Portuguese population was not exposed to radioactive contamination levels higher than the radioactive background. Therefore, there is no need to adopt any measures for radiological protection of the population. All the data are published in Internal Reports made available in the ITN website (<http://www.itn.pt>) and included in the European Radioactivity Environmental Monitoring Database (REM) located at the EU Joint Research Centre, ISPRA (Italy).

### Published work

M.J. Madruga, F.P. Carvalho, M. Reis, J. Alves, J.A. Corisco, R. Trindade, N. Pinhão, J.M. Oliveira, A. Libânio, A. Mourato, G. Silva, L. Portugal, I. Lopes, L. Silva, J. Abrantes, L. Torres, M. Malta, A.R. Gomes, G. Carvalhal, H. Fonseca, J. Melo, M. Pereira, A. Batista. *Programas de Monitorização Radiológica Ambiental (Ano 2008)*. *Internal Report DPRSN, Série A, nº33/2009*, ISBN 978-989-96542-0-4, Depósito Legal 194022/03, pp. 143.

**Biomass Combustion and Release of Radionuclides into the Atmosphere***F.P. Carvalho, J. M. Oliveira*

A collaborative project with University of Aveiro, funded by FCT, was given continuation to evaluate the release into the atmosphere of several contaminants including organic substances, toxic metals and radionuclides. The extension of forest fires in Portugal as well as around the entire Mediterranean basin is a non negligible source of toxic substances and contaminants, including natural radionuclides and artificial radionuclides deposited on surface soils following the Chernobyl accident. Several experimental approaches were assessed including measurements during true forest fires, measurements during small scale programmed fires, and laboratory burning of plant biomass.

---

**Marine Radioactivity***F.P. Carvalho, J. M. Oliveira, M. Malta*

Man-made, such as  $^{137}\text{Cs}$  and  $^{239+240}\text{Pu}$ , and naturally-occurring radionuclides such as  $^{210}\text{Pb}$  and  $^{210}\text{Po}$ , are introduced in the ocean by atmospheric deposition and coastal discharges. Research and monitoring of radioactivity in marine organisms was carried out in order to pursue the assessment of radiation doses from naturally-occurring and man-made radionuclides to biota and to the human population through ingestion of sea food. Monitoring of radionuclide levels along the Portuguese coast was performed using mussels as bioindicator organisms collected at various sites on the open coast and in the main harbours. Determination of radionuclides in mussels, fish and marine mammals (dolphins) was used to compute radiation doses to biota. This was part of a Master Thesis (M. Malta). Atmospheric radionuclide depositions in the North East Atlantic were assessed through analysis of soil samples from Azores.

---

**Project “CAPTAR”***F.P. Carvalho*

Participation in the web based education project coordinated by the University of Aveiro and funded by the Calouste Gulbenkian Foundation. The project aims at producing a scientific periodical (Captar: ciência e ambiente para todos) available on line (<http://captar.web.ua.pt/>) for education and motivation of students and young researchers in environmental sciences. Two journal issues were released in 2009.

---

**Radiocaesium Adsorption/Desorption on Geomaterials from “Raña” Deposits***M.J. Madruga, E. Andrade<sup>1</sup>, I. Paiva, I. Bobos<sup>1</sup>*

This study concerns the characterization of geomaterials from “Raña” deposits for radiocaesium adsorption and is part of a research project KADRWaste, funded by FCT<sup>2</sup> whose aim is to establishing methodologies for the characterization of medium and low activity radioactive waste repositories. It is very important to select geomaterials which can be used as effective barriers in radioactive waste disposal sites, in order to avoid migration of radionuclides in case of accident/incidents. The main objective of this study is to know the radiocaesium ( $^{137}\text{Cs}$ ) behavior in a specific geomaterial denominated “Raña” and to evaluate its potentialities as lining materials for radioactive waste repositories. This radionuclide is part of the radioactive waste inventory resulting from the application of radioactive materials in health, industry, teaching and research activities. Two geomaterial size fractions (<36 $\mu\text{m}$  and <63 $\mu\text{m}$ ) were characterized in terms of pH, organic material content, cationic exchange capacity (CEC), adsorption capacity of specific adsorption sites (*Frayed Edges Sites* - FES) and Radiocaesium Interception Potential (RIP) of potassium ion. The characterization of these geomaterials is still at a very preliminary stage. Therefore, the results obtained up to now do not allow to concluding for the uses of these materials as protection barrier in radioactive waste repositories. More research studies concerning the adsorption/desorption behavior of radiocaesium in these materials will be developed.

<sup>1</sup>Faculty of Sciences, University of Porto

---

**Accreditation of Radioanalytical Techniques***M.J. Madruga, I. Lopes, A. R. Gomes, J. Melo, J. A. Corisco*

In order to achieve the accreditation of the radioanalytical techniques the elaboration, according to the ISO/IEC 17025 Standard, of the management and technical procedures to the alpha/beta measurements using proportional counter and Liquid Scintillation Counting (LSC) as well as to the tritium determination by LSC in waters has been performed. Same improvements were implemented on these methods, mainly concerning the quality assurance. The accreditation procedure for these three techniques was submitted to Instituto Português de Acreditação (IPAC) in October 2009. In the framework of the IAEA project (RER/0/031-Strengthening Sustainability of Nuclear Research and Development Institutes in the Modern Science and Technology Environment) the Group host the visit of five AIEA experts on QA/QC and accreditation procedures and a Group collaborator spend two weeks for training in tritium measurements in waters at CIEMAT (Spain).

**Indoor Radon Measurements***M. Reis, H. Fonseca*

During 2009 some improvements were implemented regarding the indoor radon measurements using solid state nuclear track detectors (SSNTD). New film supports were acquired and are now in use. The new supports are more users friendly and allow a better protection of the LR115 film, avoiding unexpected exposures and wrong handling of the detectors by the costumers. A new geometry for the film reading is now in use, which implies changes in the etching process. Some modifications to the usual procedures were also implemented in order to improve the quality assurance.

Efforts were made in order to implement in the near future the use of seasonal correction factors.

We receive a scientific visitor (1 week) from University of Extremadura, Spain, for training in radon measurements using SSNTD and for intercomparison of continuous radon monitors.

---

**SERVICES****1. Radioactivity in Drinking and Mineral Waters***M.J. Madruga, J. Melo, A.R. Gomes, A. Libânio, I. Lopes, F.P. Carvalho, J.M. Oliveira*

Regarding the evaluation of the radioactivity levels in drinking waters (Decree-Law n°306/2007) the UPSR was requested by Water Suppliers to carry out the determinations of global alpha, global beta, Tritium,  $^{238}\text{U}$ ,  $^{234}\text{Th}$ ,  $^{226}\text{Ra}$  and  $^{210}\text{Po}$  and the Total Indicative Dose parameter in waters. The determination of Radon in same water samples was also carried out. To license the mineral waters trade an evaluation of its radioactive levels should be performed (Decree-Law n°84/90). The radiological study included analyses of  $^{226}\text{Ra}$  and global beta. Several enterprises often request this radiological study.

During 2009, a total of about 300 analyses were performed.

**2. Indoor Radon***M. Reis, H. Fonseca*

Following the National System of Building Energetic Certification for the Indoor Air Quality (Decree-Law 78/2006, 4<sup>th</sup> April) public and private enterprises request to GRA the measurements of indoor radon. Besides, since November 2003 a collaborative Protocol was established between UPSR-ITN and DECO to answer the associate's indoor radon requests.

In 2009, about 550 measurements were performed and around 800 requests are going on.