

# Environmental Radioactivity

*Maria José Madruga*

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The Environmental Radioactivity group is the only technical body in the country with specialised equipment and trained staff suitable to fulfil the State's national and international obligations in this field (ex. Artº 35 and Artº 36 EURATOM Treaty). Recently, the Law Decree 138/2005 of 17<sup>th</sup> August affirms this ability. In this context a National Radiological Environmental Monitoring Programme is on going. This programme consists on measuring the natural and artificial radionuclides in: aquatic ecosystems, mainly rivers, whose basins receive effluents from Spanish nuclear power plants (ex. Tejo River), estuaries and portuguese coast; terrestrial environmental radioactivity (foodstuffs, drinking water, soils, etc.) due to the atmospheric fallout or enhanced natural radioactivity and, atmosphere radioactivity (rainwater and aerosols) due to the anthropogenic radionuclides and cosmic radiation.

Current research project are on going to investigate the levels of radioactive contamination in and around the old uranium mining sites in order to assess the radiological risk for the population and to assist with defining priorities for environmental rehabilitation.

Studies concerning the determination of indoor radon concentrations, radon exhalation from building materials and radon mitigation measures are also persued.

The technical services developed by this group are often carried out under contract with companies or, by request from enterprises or Government organizations. Some of these technical services are: the evaluation of the radioactivity levels in public water supplies (Decree-Law nº243/2001) and mineral waters, the radioactivity analyses of foodstuffs, goods and building materials to export, and indoor radon measurements. The group income of these technical services was about 80 000 €.

During this year the group have participated in the elaboration of administrative and technical procedures following the NP EN ISO/IEC 17025 having as main objective the accreditation of global alpha, global beta and tritium measurements techniques. An environmental database was implemented, in which all the internal and external samples, the techniques associated to the analyses, the results and the respective analyses reports are recorded.

In 2005, the group participated in coordination with the DPRSN/Measurement Unit in three international inter-comparison exercises: The first one, organized by the European Commission in the framework of the Artº 35, concerning the determination of <sup>40</sup>K, <sup>90</sup>Sr and <sup>137</sup>Cs in milk powder; the second, organized by the IAEA, for the measurements of anthropogenic and natural radionuclides in mussel samples; and, the third for the determinations of natural and artificial radionuclides in vegetables ashes, organized by the Consejo de Seguridad Nuclear (Spain). The results will be published next year. The results published in 2005 concerning previous exercises were good and in one case were considered excellent.

An important part of the output of the group has been the training of young students. In the framework of the EURATOM/Radiological Environmental Monitoring Programme, five fellows have been awarded with FCT grants.

The main concern of the group is the lack of human resources. To fulfil the State's national and international obligations (Artº 35 and Artº 36 EURATOM Treaty) is absolutely necessary specialized technical personnel. During 2005 three technicians were retired and one is waiting the retirement decision. We sincerely hope that this problem might be solved rapidly.

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## Research Team

### Researchers

M. J. MADRUGA, Princ. , Group Leader  
F. P. CARVALHO, Princ.  
M. REIS, Aux.  
J. A. CORISCO, Assist.

### Students

A. R. GOMES, Graduate, FCT grant  
A. S. LEMOS, Graduate, FCT grant  
E. OLIVEIRA, Undergraduate, FCT grant  
F. RODRIGUES, Graduate, FCT grant  
H. FONSECA, Graduate, FCT grant

### Technical Personnel

M. M. SEQUEIRA  
G. FERRADOR, (retired since August 2005)  
J. M. OLIVEIRA  
M. A. GAMEIRO, (retired since November 2005)  
A. LIBÂNIO  
M. A. TAVARES, (retired since February 2005)  
M. A. PEREIRA

### Collaborators

I. LOPES  
M.M. MALTA

## MinUrar- Uranium mines and their residues: health effects in the population

F.P. Carvalho, M.J. Madruga, M. Reis, J.G. Alves, J.M. Oliveira, I. Lopes, P. Duarte, O.M. Gil, M.L. Pedro, P.A. Cardoso, M. Malta, A. Libânio, L.M. Torres, L. Silva

### Objectives

Portugal has a legacy of near sixty old uranium mining sites. Some of them, especially the site of Urgeiriça, were of a large scale mining and had facilities for uranium ore treatment. The residues contain elevated levels of radioactivity and, potentially, may expose the population to significant radiation doses with detrimental effects on health. This project was designed to investigate if a general population of Central Portugal, living within a short distance of abandoned uranium mines and its tailings show health effects associated with that exposure. The research encompassed measurement of radioactivity in environmental samples, including soil, water and agricultural products, radon in the atmosphere and environmental radiation doses, as well as a detailed clinical and genotoxic investigation in groups of human population living in counties (“freguesias”) with uranium tailings and in counties located far from the tailings. This project, also known by the acronym MinUrar, was funded by the Ministry of Health (500,000€), started in late 2002, and aims at assessing the radioactive contamination in the areas of uranium mining and milling, at assessing the exposure of population living in those areas to ionizing radiation and, ultimately, at assessing the effects on public health. It is a multi-disciplinary project with the participation of the National Institute of Health (INSA), the Geological Survey (former IGM, now INETI) and the Health Authority of the Centre of Portugal.

### Results

Concentrations of radionuclides, such as uranium and thorium isotopes,  $^{226}\text{Ra}$ ,  $^{210}\text{Pb}$  and  $^{210}\text{Po}$ , were enhanced in mill tailings and in mine waters, as well as in surface waters near the facilities of uranium ore treatment. Concentrations of these radionuclides in contaminated soils may be up to 200 times higher than concentrations in agriculture soils of the region. With increasing distance to the tailings and mining waste heaps, the concentrations of radionuclides decrease rapidly to background values. The same trend is observed with environment radiation doses that may reach 20  $\mu\text{Sv/h}$  on U tailings and decrease to values near 0.2  $\mu\text{Sv/h}$  on agriculture fields. Therefore, radiation doses received by people living near the uranium mill tailings may be higher than the radiation dose from the natural background. Regarding toxic metals, despite the complexity of the element distribution patterns found, it was possible to recognize geochemical trends in the concentrations of a set of elements that is positively correlated with the vicinity of uranium mineralization and uranium mining works. In general, levels of radiation and toxic

metals were higher in the environment of counties with old mines and tailings than in most of the comparison counties. In the study on individuals, it was found that concentrations of Pb and Zn and also Cu in blood serum were higher in exposed population than in non-exposed population. Polonium ( $^{210}\text{Po}$ ) in human hair was also higher in the population living near uranium mineralization and mining works.

The results show a slightly elevated exposure to ionising radiation and to heavy metals of population groups living near the uranium mines and mill tailings. The epidemiological study identified effects in public health in the same population groups when compared with reference groups of the population. The most plausible cause for the differences is the exposure to uranium mining residues.

The Scientific Report released in 2005 was awarded with a Distinction (“Menção Honrosa”) of the Public Health Prize Dr. Ricardo Jorge.



### Published or in press work

1. F.P. Carvalho, J.M. Oliveira, M.J. Madruga, I. Lopes, A. Libânio, L. Machado. Contamination of Hydrographic Bassins Mining Areas of Portugal. In: *Uranium in the Environment, Mining Aspects and Consequences*, B.J. Merkel and A. Hasche-Berger Ed. Springer-Verlag Berlin Heidelberg (2005) 691-702.
2. J.M. Falcão, F.P. Carvalho, M. Leite, M. Alarcão, E. Cordeiro, J. Ribeiro *et al.* MinUrar- Minas de Urânio e seus Resíduos: Efeitos na Saúde da População. *Relatório Científico I*, July 2005, Publ. INSA, INETI, ITN pp. 147.

### Environmental Radioactivity Survey Network <sup>1</sup>

*M.J. Madruga, M.M. Sequeira, G. Ferrador, M.A. Gameiro, M. Reis, I. Lopes, M.A. Pereira, F.P. Carvalho, J.M. Oliveira, A. Libânio*

The main goal of this national radiological survey consists on measuring artificial and natural radionuclides in environmental compartments (aquatic, terrestrial and atmospheric environments) considered as direct pathways of contamination to man. This programme has been planned in accordance with the European Network for Environmental Radioactivity, following the requirements of Artºs 35 and 36 of the EURATOM Treaty.

Around 400 samples have been collected accordingly to international sampling procedures and about 1000 analyses were performed for the determination of artificial and natural radionuclides, using gamma and alpha spectrometry, alpha/beta measurements and liquid scintillation technique. The determination of anionic and cationic concentrations in superficial waters, using the ionic chromatographic method has also been carried out. The results show that the Portuguese population was not exposed to radioactive contamination levels higher than the radioactive background. The estimated radiation dose to the Portuguese population due to inhalation and ingestion of the artificial and natural radionuclides measured in these samples has no significance from the point of view of radiological protection. The values obtained are much lower than those recommended to the radiological protection of the population (96/29 EURATOM Directive). Therefore, there is no need to adopt any recommendation for radiological protection. All the data were reported in Internal Reports, included into the database Easy Proteo 4.11 and sent to the EU Joint Research Centre, ISPRA, where later on were introduced into the European Database (REM).

<sup>1</sup> In coordination with DPRSN/Measurement Unit

### Artificial Radioactivity in the Tagus Estuary <sup>1</sup>

*F. P. Carvalho, J. M. Oliveira, A. Libânio, M. Malta*

The discharges of liquid waste containing artificial radionuclide into the sewage system of Lisbon have been detected and followed for years. Most of these radioactive discharges originate in the use of radioisotopes in hospitals. Other potential sources are nuclear powered ships, industrial facilities and research laboratories including the ITN. As a large fraction of the liquid waste from the city is discharged either treated or untreated into the estuary of the Tagus, the determination of concentrations has been made in sediment, water and fish samples collected monthly in various zones of the estuary between Sacavém and Algés. The most frequently detected radionuclides are <sup>99m</sup>Tc ( $T_{1/2} = 6$  h) and <sup>131</sup>I ( $T_{1/2} = 8$  d). Both technetium and iodine are usually measured in environmental samples, including fish, especially in those collected near the discharge of main sewers, such as Alcântara and Terreiro do Paço, indicating that waste storage to allow for radioactive decay is insufficient or does not exist in some facilities. Nevertheless, radionuclide concentrations in water and fish are generally below 10Bq kg<sup>-1</sup> and, therefore, it is unlikely that they pose a significant radiological risk to the population.

<sup>1</sup> In coordination with DPRSN/Measurement Unit

## SERVICES

### 1. Radioactivity in Drinking and Mineral Waters <sup>1</sup>

*M.J. Madruga, G. Ferrador, M.M. Sequeira, E. Oliveira, A.R. Gomes, F. Rodrigues, J.M. Oliveira, I. Lopes*

Following the Portuguese Law (Decree-Law nº243/2001) it is compulsory the evaluation of the radioactivity levels in drinking waters. For this purpose the DPRSN was requested by Water Suppliers to carry out the determinations of global alpha, global beta, Tritium, <sup>238</sup>U, <sup>234</sup>Th, <sup>226</sup>Ra and <sup>210</sup>Po and the Total Indicative Dose parameter in drinking waters. The determination of radon in same water samples was also carried out. In order to obtain license to the commercialisation of mineral waters, an evaluation of its radioactive levels should be performed (Decree-Law nº84/90). The radiological study included analyses of <sup>238</sup>U, <sup>234</sup>Th, <sup>226</sup>Ra, <sup>222</sup>Rn, <sup>210</sup>Po and global beta. Several enterprises often request by this radiological study. During 2005, a total of about 1400 analyses were performed.

### 2. Radioactivity in Foodstuffs and other Samples <sup>1</sup>

*M.J. Madruga, M. A. Gameiro, A.S. Lemos*

By request of public and private enterprises, different kind of samples to be exported, mainly food samples and building materials were monitored. During this year 48 samples were analysed.

### 3. Indoor Radon

*M.J. Reis, H. Fonseca*

By request of public and private enterprises indoor radon measurements were performed in buildings. Since November 2003 a collaborative Protocol was established between DPRSN-ITN and DECO to answer the associate's indoor radon requests. A total of 160 measurements were performed during this year.

<sup>1</sup> In coordination with DPRSN/Measurement Unit