

Epidemiological Study of the Effects of Uranium Mining Residues

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Objectives

This project, also known by the acronym MinUrar, was 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

During 2004 several field sampling campaigns were carried out in the counties selected for the investigation. In every county, samples of agriculture soil, water, vegetables, milk, aerosols, were collected. Measurements were made in situ for external radiation dose rate and radon concentrations. Integrative radon dosimeters and thermo-luminescent dosimeters (TLDs) were placed in houses as well as at outside locations for comparison purposes. Literally, hundreds of samples were analyzed by alpha spectrometry, gamma spectrometry, and liquid scintillation counting.



A preliminary assessment of the contamination of the sites was made, based on the presence or absence of uranium tailings and mine waters. Most of the old uranium mining sites do not show enhanced radiation doses and enhanced concentrations of radionuclides.

The most contaminated sites are a few, where uranium ore was chemically treated and where sulfuric acid was applied for in situ leaching of uranium. Preliminary reports were given at a International Workshop on Environmental Contamination from

Uranium Production Facilities and Remediation Measures, organized by the ITN/DPRSN, in Sacavém, with the support of the IAEA, and participation of ENUSA (Spain), IPSN and COGEMA (France). The Proceedings of this Workshop are in press. A progress report was also prepared by the coordination committee of the MinUrar project and made available to the public. The final Report of the project is planned for next year.

Published, accepted or in press work

1. F.P. Carvalho, J.M. Oliveira, A. Libânio, I. Lopes, G. Ferrador, M.J. Madruga. Radioactivity in Public Water Supplies in the Uranium Mining Regions of Portugal. Internat Workshop on Environ. Contamination from Uranium Production Facilities and Remediation Measures, organized by the ITN/DPRSN and the IAEA, Sacavém, 11-13 Feb 2004 (in press)
2. F.P. Carvalho, M.J. Madruga, M.C. Reis, J.G. Alves, J.M. Oliveira, J. Gouveia, L. Silva. Radioactive survey in former uranium mining areas in Portugal. Intern. Workshop on Environ Contamination from Uranium Production Facilities and Remediation Measures, organized by the ITN/DPRSN and the IAEA, Sacavém, 11-13 Feb 2004 (in press)
3. L. Silva, M.J. Madruga, C. Dovelete, F.P. Carvalho, M. Reis, J. Gouveia, J. Corisco, L. Ramos. Comparison of in-situ and laboratory gamma spectrometry of natural radionuclides in uranium mill tailings. Internat Workshop on Environ. Contamination from Uranium Production Facilities and Remediation Measures, organized by the ITN/DPRSN and the IAEA, Sacavém, 11-13 Feb 2004 (in press)
4. F. P. Carvalho, M. J. Madruga, M. C. Reis, J. M. Oliveira, J. G. Alves, A. Libânio, J. M. Gouveia, L. Silva. Minas de urânio e contaminação ambiental no centro-norte de Portugal. Uma avaliação preliminar. 8ª Conferencia Nacional do Ambiente, Lisboa, 27-29 Outubro 2004 (ed. in CD-ROM).
5. P. Duarte, J.J. Silva, M.J. Reis. Radão no interior de habitações do concelho de Nisa, 8ª Conferência Nacional de Ambiente, Lisboa, 27-29 October 2004, (ed. in CD-ROM).

Environmental Radioactivity Survey Network

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Objectives

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.

Results

Samples of superficial waters, sediments and fish from Tejo (monthly, V. Velha de Ródão and Valada; quarterly, Barragem de Fratel and Berver), Zezêre (monthly, one sampling site), Guadiana, Mondego and Douro (annually, one sampling site) rivers have been collected. Marine samples (sediments, seaweeds and mussels) have been collected annually in five sampling sites along the Portuguese coast (Matosinhos, Figueira da Foz, Cabo de S. Vicente, Tejo and Sado estuaries). Samples of drinking water have been taken monthly in Sacavém, V. Velha de Ródão and two other localities selected at random in the country. Rainwater samples have been collected monthly at Sacavém and Castelo Branco. In what concerns the terrestrial compartment, samples of soils (annually, from four different regions in the country), mixed diet products (monthly, from 10 different regions), complete meals (quarterly) and milk (monthly, two samples) have been collected. Aerosols samples have been taken (weekly) in Sacavém. The sampling sites are shown in Fig. 1.

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 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 biological and sanitary effects. The values obtained are much lower than those recommended to the population for radiological protection (96/29 EURATOM Directive). Therefore, there is no need to adopt any recommendation for radiological protection. All the data were reported in Internal Reports [2] included into the database Easy

Proteo 4.11 and sent to the EU Joint Research Centre, ISPRA, where they were introduced into the European Database.

In the framework of the Artº 35 an intercomparison exercise on airborne particles organized by the European Commission was carried out during this year.

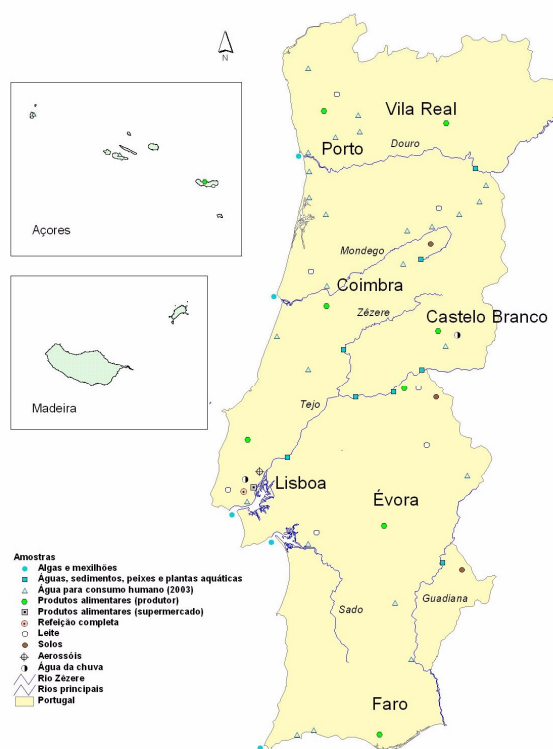


Fig. 1- Sampling sites for the aquatic, terrestrial and atmospheric environments

Published, accepted or in press work

1. M.J. Madruga, F.P. Carvalho, M. Reis, M.M. Sequeira, G. Ferrador, M.A. Gameiro, L. Silva, J. Gouveia, L. Machado, J.M. Oliveira, I. Lopes, V. Silvino (2004). *Vigilância Radiológica do Ambiente em Portugal*. 8ª Conferência Nacional de Ambiente, Lisboa, 27-29 Outubro 2004 (ed. in CD-ROM).
2. M.J. Madruga, F. Carvalho, M.M. Sequeira, G. Ferrador, M.A. Gameiro, M.Reis, L. Silva, J. Gouveia, L.Ramos, J.M. Oliveira, L. Machado, I. Lopes, M.A. Pereira, M.A. Tavares, A. Libânio, V. Silvino. *Vigilância Radiológica a Nível Nacional (Ano 2003)*. Relatório DPRSN, Série A, nº28/2004, ISBN 972-8660-29-4, Depósito Legal 194022/03.

Water Quality and Radioactive Contamination

F. P. Carvalho, I. Lopes, M. J. Madruga, J. M. Oliveira, G. Ferrador, M. Sequeira

Objectives

Water quality for human consumption is a priority issue both at national level as well as at the international level. Radioanalytical techniques have been applied extensively to determine concentrations of naturally-occurring radionuclides as well as radionuclides of anthropogenic origin in surface waters and underground waters. These measurements did allow a preliminary characterization of water composition and serve the purpose also of monitoring its suitability for human consumption.

Results

Water samples from various regions of the country were analyzed using several techniques (Fig 1). Surface waters from various regions, taken mainly in artificial lakes in rivers, are in general in conformity with the EU and national recommended limits for total alpha and total beta radioactivity in water for human consumption (Fig 2).

Underground waters tend to display higher concentrations of dissolved radionuclides belonging to the uranium series, such as uranium, radium and lead isotopes. Radon dissolved in water is also generally higher in underground waters than in surface waters. Uranium concentrations, and partly radium also, are positively correlated with the total concentrations of dissolved salts.

In granite regions, including areas where uranium mining and milling took place, especially when acid mine waters are present, the concentrations of radionuclides in underground waters are enhanced due to leaching of uranium radionuclides from the host rock. For instance, in the region of Cunha Baixa, an uranium old mine near Mangualde, the water in wells contain ^{238}U concentrations ranging from 11 to 256 mBq L^{-1} . There is a positive correlation between these concentrations and the pH of waters.



Fig. 1 – Collection of water sample for radon analysis.

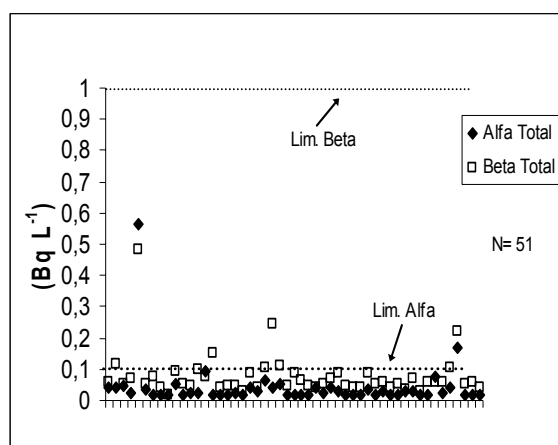


Fig. 2 – Total alpha and beta activity in water for human consumption.

Published, accepted or in press work

1. I. Lopes, M.J. Madruga, F.P. Carvalho (2004). Application of Liquid Scintillation Counting Techniques to Gross Alpha, Gross Beta, Radon and Radium Measurements in Portuguese Waters. NORM IV Conference, Naturally Occurring Radioactive Materials”, Szczyrk, Poland, Maio 2004 (ed. in CD-ROM).
2. F. P. Carvalho, M. J. Madruga, J. M. Oliveira, I. Lopes, M. M. Sequeira, G. Ferrador (2004). Qualidade Radiológica da Água para Consumo em Portugal: Águas de Superfície e Águas Subterrâneas. 11º Encontro Nacional de Saneamento Básico, Faro, Universidade do Algarve, 12 a 15 Outubro 2004 (ed. in CD-ROM).
3. I. Lopes, F. P. Carvalho, M. J. Madruga, J. M. Oliveira, G. Ferrador, M. Sequeira (2004). Qualidade da Água de Consumo: Monitorização dos Parâmetros Radiológicos. VIII Conferência Nacional de Ambiente, 27 a 29 de Outubro 2004, Lisboa (ed. in CD-ROM)
4. F. P. Carvalho, A. Dill, J. Fernandes, C. C. Almeida, J. M. Oliveira, G. Ferrador, I. Lopes (2004). Estudo Sobre a Contaminação do Sistema Aquífero da Margem Sul do Tejo, na Zona de Corroios e Amora. VIII Conferência Nacional de Ambiente, 27 a 29 de Outubro 2004, Lisboa (ed. in CD-ROM).

Artificial Radioactivity in the Tagus Estuary and along the Portuguese Coast

F. P. Carvalho, J. M. Oliveira, A. Libânio, M.J. Madruga, L. Silva, J. Gouveia, M. Malta

Objectives

The estuary of the Tagus River receives drainage from the city of Lisbon, discharges of several industries located in the river banks and may receive discharges from nuclear powered vessels visiting the port of Lisbon. Furthermore, there are nuclear reactors installed on the hydrographic basin of the Tejo that may originate discharges of radionuclides into the estuary. Due to intense navigation of merchant ships with radioactive cargo and nuclear powered vessels in Portuguese waters, the risk of an accidental release of radioactivity is not null. A periodic assessment is made including an assessment of contamination of seafood.

Results

The monthly sampling of water sediments, mussels and fish in the estuary of the Tagus (Figs 1 and 2) allowed to frequently measure short lived isotopes such as ^{131}I and $^{99\text{m}}\text{Tc}$. These isotopes were detected in concentrations up to 24 Bq kg^{-1} in mussels and up to 90 Bq kg^{-1} in fish. The highest concentrations were always detected near the outlet of the main sewers from the city of Lisbon, and the radionuclides were traced back to the discharge of liquid effluents from hospitals and nuclear medicine facilities. Cs-137, a long lived radionuclide, was frequently detected in the sediments of the estuary in concentrations less than 3 Bq kg^{-1} (dry weight). This man made radionuclide is not from the domestic discharges. Instead it was deposited after the test of nuclear weapons in the 50s and 60s. Higher concentrations have been measured in surface soils in the Continent and in the islands. It is interesting to note that in the estuary in front of ITN the short lived radionuclides were never detected. Other artificial radionuclides have not been detected.

Along the coast, periodic the collection of mussel and seaweed samples have been made. Analyses by gamma spectrometry do not show radioactive contamination. Analyses by alpha spectrometry show very low concentrations of plutonium, probably originated also in the fallout of atomic debris.

Analysis of fish that are part of the current diet of the Portuguese do not show high concentrations of artificial radionuclides, such as Pu, Am, Cs-137 or other. Furthermore, fish from Portuguese waters contain concentrations of artificial radionuclides lower than fish from the North Sea.

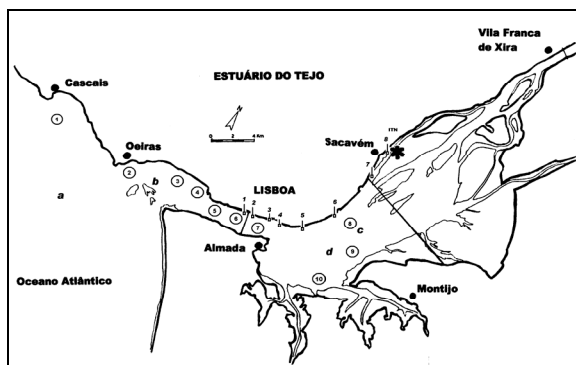


Fig. 1. Points of sample collection in the Tagus estuary



Fig. 2. Sample collection in the Tagus estuary

Published, accepted or in press work

1. F. P. Carvalho, J. M. Oliveira, A. Libânio, M. J. Madruga, L. Silva, J. Gouveia, P. Monteiro, M. Perdigão, M. Malta (2004). Avaliação da Contaminação do Estuário do Tejo por Substâncias Radioactivas de Várias Origens. VIII Conferência Nacional de Ambiente, 27 a 29 de Outubro 2004, Lisboa (ed. in CD-ROM).
2. F.P. Carvalho, M.J. Madruga, J.M. Oliveira, J.M. Gouveia, L. Silva (2004). Radioactivity in the Northern Seas of Europe. Radioprotecção 2: 118-125.

European Radon Research and Industry Collaboration Concerted Action (ERRICCA-2)

M.C. Faísca, F.P. Carvalho, P.M. Duarte, M. Reis

Objectives

The principal objective of the concerted action is in establishment of a new European scientific led industrial forum to reduce risks to health from radiation (principally radon) in the built environment. The forum which will operate on both European and National levels will help in:

- Disseminating existing research findings to industry and the public,
- Clarifying industry needs for further research,
- And for undertaking collaborative work in common topic areas.

Results

Building Materials and Radon barriers

Radon exhalation rates measurements were carried out in different Portuguese building materials.

Mapping and measurement

All the indoor radon data previously obtained from the radon national survey was crossed with geological information (using Geographic Information Systems) with the aim to produce a better and clear mapping of radon risk and radon affected areas. Geological polygons will replace old administrative polygons, once they are more representative and statistically significant. The database was reinforced in radon affected areas, in order to improve the quality of indoor radon risk mapping.

European radon web site

Preparation of the contents for a radon web page to be linked to the European Radon web site.

Meetings

Participation on the 5th European Radon Forum, held in UK, 27-28 September 2004.



Published, accepted or in press work

1. P. Duarte, J.J Silva, M.J. Reis, Radão no interior de habitações do concelho de Nisa, *Proceedings of the 8^a Conferência Nacional de Ambiente, Lisboa, 27-29 October 2004* (ed. in CD-ROM)

Services

1. Radioactivity in Drinking Waters

M.J. Madruga, G. Ferrador, M.M. Sequeira, I. Lopes, M.A. Tavares, M.A. Pereira

Following the Portuguese Law (Decree-Law nº243/2001) it is compulsory the evaluation of the radioactivity levels in public waters (human consumption). For this purpose the DPRSN was requested by Water Suppliers to carried out the measurements of global alpha, global beta, Tritium and the calculations of Total Indicative Dose parameter in drinking waters. The determination of radon in same water samples was also carried out.

During 2004, a total of about 2000 analyses were performed.

In order to better answer to this request the administrative and technical procedures for accreditation of global alpha, global beta and Tritium radiochemical analyses has been carried out.

During this year the Environmental Radioactivity Group has participated into an intercomparison exercise between laboratories of Environmental Radioactivity, for drinking water, organized by the Consejo de Seguridad Nuclear (Spain). The results obtained for global alpha, global beta and Tritium were within the reference values.

2. Natural Radioactivity in Mineral Waters

M.J. Madruga, G. Ferrador, J. M. Oliveira, M.A. Tavares

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 will include analyses of ^{238}U , ^{234}Th , ^{226}Ra , ^{222}Rn , ^{210}Po and global beta. Several enterprises often request by this radiological study. A total of 25 analyses were performed during this year.

3. Artificial Radioactivity Levels in Foodstuffs and other Samples

M.J. Madruga, L. Silva, J. Gouveia, M. A. Gameiro

By request of public and private enterprises, different kind of samples to be exported, mainly food samples and building materials were monitored in order to determine concentrations of artificial and natural radionuclides by gamma spectrometry. During this year 80 samples were analysed.

4. Indoor Radon

M. Reis, P. Duarte

By request of public and private enterprises indoor radon measurements were performed in buildings. A total of 10 analyses were performed during this year.

Since November 2003 a collaborative Protocol was established between DPRSN-ITN and DECO to answer the associate's indoor radon requests. A total of 150 measurements were performed during this year.