Department of Radiological Protection and Nuclear Safety

Department of Radiological Protection and Nuclear Safety

Fernando P. Carvalho

The role of the Department of Radiological Protection and Nuclear Safety (DPRSN) in our society was again valued and appreciated by various sectors due to scientific and technological timely actions carried out during 2002.

The work performed by the DPRSN includes the completion of data bases of radiation doses received by workers since the beginning of individual dosimetry in Portugal, the assessment of radiation safety of 520 installations, the in situ verification of 80 facilities, the completion of a preliminary survey of radioactivity in 50 old uranium mines, the intervention in 12 cases to recuperate lost radioactive sources and individual monitoring of about 10000 radiation workers. Adds to these, the regular monitoring of foodstuff and water that are the daily diet of the Portuguese population, the radiological surveillance of the Tagus river and of several large water reservoirs that supply main cities, the periodic monitoring of the atmosphere, calibration of radiation meters and specialized medical devices, and recuperation and storage of radioactive waste.

Research projects were carried out, with external or national funding resources, such as the research on the effects of low doses of ionizing radiation and apoptosis, the transport of radioactivity in different classes of aerossol particles, the external radiation doses and environmental transport of radionuclides in abandoned uranium mining sites, and radon in the indoor air. Monte Carlo applications were also developed to radiation transport in specialized medicine areas and radiation dosimetry.

Contract work was performed also by the DPRSN, providing valuable services to various economic sectors of the country. These technical services include analysis of commodities and foods to external markets to certify that they are not contaminated with radionuclides, analyses of water to certify that they are suitable for human consumption or analysis of radon in buildings (workplaces) to investigate whether abnormally high radon concentrations are present. These are just a few examples taken from a wide variety of cases where DPRSN could act positively to assist manufacturing companies, hospitals, industrial exporters, local authorities, and other sectors of our society. We could feel in all occasions the importance of our intervention and we believe that this is the sense and the meaning of a State Laboratory.

Proposals for new research projects were prepared in conjunction with Universities in Spain for joint work on radiological safety in case of transbounday transport of radioactive contaminants. Expressions of interest for joint projects in radiological protection were prepared with institutes from other EU countries for the 6th EU Framework Programme, but these will eventually bloom in the next year only. Meanwhile, an important collaboration project was signed up between the National Institute of Health (INSA), the Geological Survey (IGM) and ITN-DPRSN for the performance of an epidemiological study on the effects of uranium mining residues in the population. This is a 0.5 million Euros project for 3 years, and will mobilize a large contribution of DPRSN staff in the coming years. Nevertheless, it is an essential project for the country that justifies all efforts.

Training and education is another area where DPRSN has been actively working. The group of trainees working in the DPRSN under the project of Additional Resources to Radiological Protection has been able to develop their skills in a hands-on training approach and to be trained abroad with IAEA grants also. Most of the trainees have applied to jobs in Hospitals to work in radiation protection or radiation physics and left ITN-DPRSN. Although we feel that we have provided valuable training to them, we regret that none of them was hired to fill the gaps in our own Department, where human resources are scarce and far below the safe level, as noted in the last report of the ITN Advisory Committee. We sincerely hope that this trend might be inverted rapidly.

The DPRSN ensured also the national representation in various European and International Committees ranging from Metrology to Control of Radiation Sources, frequently under the auspices of AEN/OECD, IAEA, European Union, CTBT, amongst others. The legal duties and competences of DPRSN are clearly established in the Decree-Law 311/98 of 14 October. New legislation on radiation protection issued during 2002, transposing partly the EU Directives 96/29 and 97/43 (radiological protection of workers and public, and radiological protection of patients respectively), reinforces the role and responsibilities of DPRSN towards the society. The DPRSN is now in charge of the National Registry of Individual Doses, and of the National Inventory of Radioactive Sources. This will contribute to improve radiological safety, but puts an additional burden on the Department. Furthermore, this underscores the need to strengthen a consistent national system of radiological protection and nuclear safety and to develop the scientific and technical infrastructures needed by the country, as recommended by the IAEA and the EU.

Our efforts have been put in the fulfilment of these duties, as described in this report.

Staff

Director: FERNANDO P. CARVALHO

Administrative

- A. M. ROSA
- D.M. ALVES
- J. MONTEIRO
- M. A. CORDEIRO (Temporary Contract)
- M.E. PACHECO
- M.F. SILVEIRA[1]

Driver

- V. CORDEIRO

Division of Environmental Radioactivity

Researchers

- M. J. MADRUGA, Principal Researcher (Group Leader)
- A. BROGUEIRA, Principal Researcher[1]
- F. CARVALHO, Principal Researcher
- J.A. CORISCO, Research Assistant
- M. REIS, Research Assistant

Technical Personnel

- J. M. OLIVEIRA
- G. FERRADOR
- M. M. SEQUEIRA

Auxiliary Personnel

- A. LIBÂNIO
- C. COSTA
- M. A. PEREIRA
- M. A. TAVARES

Students

- A. LUCAS, MSc Student (ITN grant)
- C. PIRES[2], MSc Student (ITN grant)
- H. GUERREIRO[2] (ITN grant)
- I. LOPES, Post-Doc Student (FCT grant)
- I. FARIA (ITN grant)
- J. GOUVEIA (ITN grant)
- L. SILVA, MSc Student (ITN grant) since 11/02
- L. MACHADO, MSc Student (ITN grant)
- L. RAMOS (ITN grant)
- P. DUARTE (ITN grant)
- R. RODRIGUES[2] (ITN grant)
- S. CURADO[2] (ITN grant)
- T. FERREIRA (BSc Student – FC Lisboa)
- V. SILVINO (ITN grant)

Division of Dosimetry, Radiological Safety and Biological Effects of Ionising Radiations

Researchers

- F.P. CARVALHO, Principal Researcher, (Provisional group leader)
- A. OLIVEIRA, Auxiliary Researcher
- E. AMARAL, Auxiliary Researcher
- J. ALVES, Auxiliary Researcher
- J. P. LUIS, Principal Researcher
- M.A. NEVES, Principal Researcher
- M.B. MARTINS, Principal Researcher
- M.L. PEDRO, Auxiliary Researcher
- O. GIL, Auxiliary Researcher

Medical Doctor

- J.R.COSTA

Technical Personnel

- G. RANGEL
- J.S. JESUS
- M.A. GAMEIRO
- M.F. FRAGOSO[1]
- M. ÂNGELO
- O. MARGO, since 03/02

Auxiliary Personnel

- A. OLIVEIRA[1]
- H. SANTOS[1]
- J. PAIVA
- M.T. LUZIO[1]

Students

- A.R.RODA, MSc Student, ITN grant
- D. MIRANDA (ITN grant)
- K. JACOB[2], MSc Student, ITN grant
- H. RAMINHOS, MSc, Student, INETI grant
- M. J.S. SILVA[2] (ITN grant)
- P. CARDOSO (ITN grant) since 10/02
- P. SILVA[2] (ITN grant)
- R. MELO (ITN grant) since 10/02
- R. MONTEZUMA (ITN grant) since 10/02
- R. VIEIRA (ITN grant) since 09/02
- S. RANGEL (ITN grant)
- S. ROSA (ITN grant)
- V. LEITE, Graduated Student, FCL

[1] Retired during 2002
[2] Left during 2002

Division of Metrology of Ionising Radiations

Researchers

- A.F. CARVALHO, Principal Researcher (Group Leader)
- C. OLIVEIRA, Principal Researcher

Technical Personnel

- L. SANTOS

Students

- J.V. CARDOSO, MSc Student (ITN grant)

Division of Operational Radiological Protection and Radioactive Waste Management

Researchers

- R. TRINDADE, Auxiliary Researcher (Group Leader)
- M.I. PAIVA, Auxiliary Researcher

Technical Personnel (Graduate)

- L. PORTUGAL

Auxiliary Personnel

- F. TEIXEIRA
- F.B. GOMES (outposted at RPI)

Students

- H. MARQUÊS (ITN grant), since 11/02
- L. BRÁS (ITN grant), since 11/02
- N. ALVES (ITN grant), since 11/02
- R. CASQUINHA[2] (ITN grant)

Funding (€)

Research Projects:	59 762
PIDDAC:	748 197 (*)
Services:	622 908
Total:	**1 430 867**

Publications

Journals:	13 and 4 in press
Proceedings:	21
Conf. Communications:	29
Internal Reports:	44

(*) Infrastrutures for Radiological Protection and Radioactive Wastes:
- Radiological Protection – 498 798 Euros
- Radioactive Wastes – 249 399 Euros

Division of Environmental Radioactivity

Division of Environmental Radioactivity

Maria José Madruga

Environmental radioactivity group is the only technical body in the country with specialised equipment and trained staff to fulfil the State's national and international obligations in this field (ex. Artº 35 and Artº 36 EURATOM Treaty). In this context a national environmental monitoring network is on going. This programme concerns the determination of natural and artificial radionuclides in aquatic ecosystems, mainly rivers, whose basins receive effluents from Spanish nuclear power plants (ex. Tejo), estuaries and Portuguese coast, in terrestrial environmental radioactivity (foodstuffs, drinking water, soils, etc.) due to atmospheric fallout or enhanced natural radioactivity and, in atmospheric radioactivity (rainwater and aerosols), due to cosmic radiation. Current research projects are related with this programme and concern the study of the mechanisms governing the transfer of natural and artificial radionuclides in the environment (aquatic, terrestrial and atmospheric).

Studies concerning the determination of indoor radon concentrations, radon exhalation from building materials and radon countermeasures are on going.

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

The group have also collaborated in the elaboration of a proposal to a new research project with Universities in Spain, submitted to the INTERREG IIIA programme Spain - Portugal Programme (2003-2004), in order to study the behaviour of natural and artificial radionuclides in Hispano-Portuguese ecosystems.

The Environmental Radioactivity Division has struggled for years with lack of space and poor conditions to operate sophisticated equipment in the current installations of DPRSN. An effort was made to improve these conditions and a new room was built, with selected low radioactivity materials, to install properly the gamma-spectrometry as well as other equipment. Although modest, this new counting room allows for more stable background counts, controlled temperature and humidity, and has a back up power supply and UPS for the counting systems.

Study of Aerosol Deposition Processes Using Natural Radionuclides as Tracers

M.J. Reis, N.R.N. Rosa[1], A.O. Bettencourt, A.L. Brogueira

Objectives

The main purpose of this project is to study aerosol transport and removal processes in the atmosphere using natural radionuclides as tracers.

Results

Natural radionuclides, either from terrestrial or cosmic origin, are continuously produced and dispersed into the atmosphere, where they rapidly attach to existing aerosol particles. Some of those nuclides remain long enough in the atmosphere to participate in the formation and growth of the accumulation mode aerosol, allowing for their use as natural tracers of aerosol transport and deposition processes.

Since the aerodynamic properties of particles are a key parameter for the understanding of the behaviour and potential effects of atmospheric radioactive aerosols, size distribution measurements and size fractionated activity composition were also considered.

The short-lived ^{214}Pb and ^{212}Pb activities are concentrated in particles with aerodynamic diameters of 0.37 μm and 0.20 μm, respectively. On the contrary, the longer half-lives of ^{7}Be and ^{210}Pb favour their interaction with the airborne aerosol longs enough to participate in coagulation processes, shifting their activities to larger particles (0.50 μm for ^{7}Be and 0.72 μm for ^{210}Pb, on average).

In estimating mean residence times of ^{7}Be labelled aerosols in the lower troposphere, a range of 4 to 14 days was obtained.

^{212}Pb and ^{214}Pb activities on vegetation surfaces were used to estimate dry deposition velocities. The obtained results (0.23 cm s^{-1} for ^{212}Pb labelled aerosols and 0.92 cm s^{-1} for ^{214}Pb aerosols) are representative of significant dry deposition fluxes in the studied area, which indicates an important contribution of dry deposition to the total deposition fluxes.

The importance of external influences on local atmospheric radioactivity levels were assessed by using ^{7}Be/^{210}Pb activity ratios, together with both nuclides combined activity in the form of a radioactive loading index. It was concluded that the occurrences of low activity ratio values were associated with air masses from continental origin. The occurrence of high relative abundance in ^{7}Be (higher values of the ratio ^{7}Be/^{210}Pb), were associated with descendent vertical movements of the aerosol carrying air masses, which promotes the transference to the lower troposphere (eventually from stratospheric origin) of ^{7}Be enriched aerosols.

Published, accepted or in press work

1. M.J. Reis, R.N. Rosa, A.L. Brogueira, A.O. Bettencourt, The use of natural radionuclides to trace dry deposition of submicron aerosols, *Radioprotecção*, Vol.II, **1** (2002) 101-109.

2. M.J. Reis, Utilização de radionuclidos naturais como traçadores no estudo de processos de deposição de aerossóis, PhD Thesis, Univ. Évora, Novembro de 2002.

[1] Physics Department of Évora University.

Environmental Survey Network

M.J. Madruga, F.P. Carvalho, M. Reis, M.M. Sequeira, G. Ferrador, J.M. Oliveira, M.A. Gameiro, A. Libanio, J. Gouveia, L. Ramos, V. Silvino, L. Machado, A. Lucas, I. Faria, M.A. Pereira, M.A. Tavares, C. Pires, S. Curado

Objectives

Determination of artificial radioactivity in samples from the aquatic, terrestrial and atmospheric environmental compartments were performed.
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, four sampling sites), Zezêre (monthly, one sampling site), Guadiana, Mondego and Douro rivers (annually, one sampling site) are collected. Marine samples (sediments, seaweeds and mussels) are collected annually in five sampling sites along the Portuguese coast (Matosinhos, Cascais-Guincho, Cabo de S. Vicente, Tejo and Sado Estuary). Samples of drinking water are taken monthly in Sacavém, V.Velha de Ródão and two other localities along the country. Rainwater samples are collected monthly in Sacavém and Castelo Branco (Figure 1a). 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) are collected. Aerosols samples are taken weekly in Sacavém (Figure 1b).
Around 400 samples are collected accordingly with international sampling procedures and about 1000 analyses for the determination of artificial radionuclides, using gamma and alpha spectrometry, alpha/beta measurements and liquid scintillation technique, were performed. The determination of the anionic and cationic concentrations in superficial waters, using the ionic chromatographic method is also performed.
All the data are reported in Internal Reports [1, 2, 3], included into the database Easy Proteo V4.1 and sent to the EU Joint Research Centre, ISPRA, where they are introduced into the European Database [4].

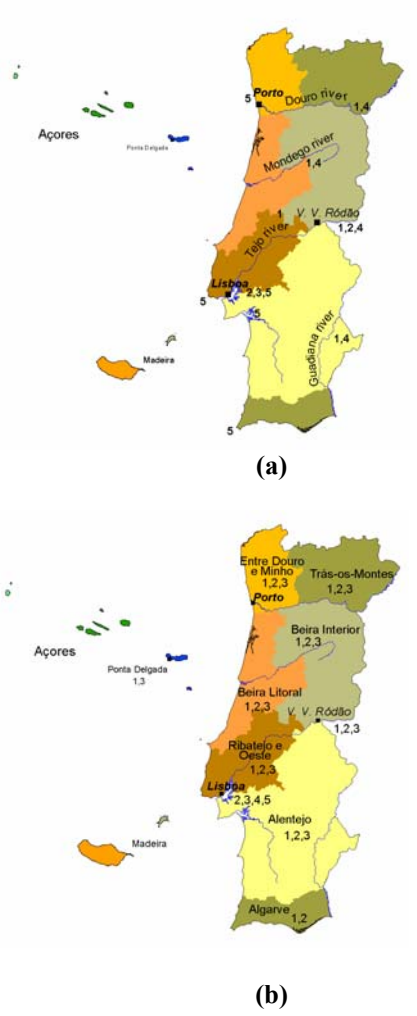


Figure 1- Sampling sites of the aquatic (a) terrestrial and atmospheric environmental (b) monitoring

Published, accepted or in press work

1. M.M. Sequeira, M.C. Faísca, G. Ferrador, M. Reis, S. Curado, C. Pires, V. Silvino, M. A. Pereira, M. A. Tavares, M.A. Gameiro, M.J. Madruga Vigilância Radiológica a Nível Nacional (1999-2001), *Relatório DPRSN, Série A, nº18/2002. ISBN 972-95401-9-5, Depósito Legal 179039/02*.
2. M.M. Sequeira, V. Silvino, M.A. Pereira, C. Pires, A. Brogueira, I. Faria, S. Curado. Radioactividade nos Rios Tejo e Zêzere, nos anos de 2000 e 2001, *Relatório DPRSN, Série A, nº19/2002. ISBN 972-8660-20-0, Depósito Legal 179040/02*.
3. M.C. Faisca, M. Reis, C. Pires, M.A. Tavares, Controlo radiológico no *"Campus"* de Sacavém (1997-2001), *Internal Report DPRSN, Série A, nº20/2002. ISBN 972-8660-19-7, Depósito Legal 179041/02*
4. Environmental Radioactivity in the European Community 1995. Radiation Protection nº 126, EUR 19929 EN. ISBN 92-894-1702-1 (2001).

Environmental Contamination in and around Old Mining and Milling Uranium Sites

F.P. Carvalho, M.J. Madruga, J.G. Alves, M. Reis, P.Duarte, J.M. Oliveira

Objectives

To investigate the current levels of radioactive contamination in and around the old mining sites in order to assess the radiological risk for the population and to assist with defining priorities for environmental rehabilitation.

Results

During the current year seven field missions were carried out to perform measurements and sampling in most of the old uranium mines. In situ gamma spectrometry, radon measurements and collection of samples for laboratory analyses (water, soil, plants and aerossols) were performed. External radiation dose measurements were carried out in most of the locations also. Several hundred samples were analysed or are in the course of analyses still.

From the results obtained so far it is clear already that in many old mining sites, open pits mainly, there are no significant radioactive contamination. In a few places, near the mine were left tailings containing either low grade uranium ore or radioactive residues of the uranium extraction. In another places, such as Urgeiriça, Senhora das Fontes, Bica, etc., there are more radioactive tailings. The amount of residues in these tailings account for several tonnes and need to be confined and stored properly.

The preliminary stage of this project for the survey of the sites, is now mostly performed.

The continuation of this project will go deeper into the more detailed investigation of radionuclide distribution and radiation doses in selected areas (highly contaminated with tailings, with Uranium mines but without tailings, and background areas). A joint research project was agreed upon between the National Laboratory for Health (INSA), the Geological Survey (IGM) and ITN-DPRSN for an epidemiological study in the uranium impacted areas.

The ITN-DPSRN has also the support of an IAEA TC Project for the radiological risk assessment in uranium mining areas (POR/4/019). In the framework of this project a scientific unit was organized with COGEMA (France) to allow for the visit of a scientist of DPRSN and IGM to uranium mines in France, October 2002.

Published, accepted or in press work

1. F.P. Carvalho (2002), Objectivos da protecção radiológica a atingir com a remediação ambiental nas antigas minas de urânio, *IX Jornadas da Sociedade Portuguesa de Protecção Contra Radiações,* Lisboa, 21-22 Novembro de 2002. Relatório DPRSN-A, nº24/2002.
2. F.P. Carvalho (2002), Environmental remediation of old uranium mining sites and radiological protection goals, *Radioprotection (in press).*
3. F.P. Carvalho and M. Machado Leite (2002), Report on the scientific visit to uranium mining sites and radioecology laboratories in France, 6-12 October 2002, ITN-DPSRN, October 2002.

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

M.C. Faísca, P.M. Duarte, F.P. Carvalho, L. Machado

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

Increasing public awareness and confidence

Edition of a booklet about radon with 12 pages (5000 copies).

Organization of the "First Portuguese Journeys about Radon and Natural Radioactivity". This Forum took place in Guarda at 4th December 2002 and they were present about 130 people.

Building Materials and Radon barriers

We have performed exhalations rates from different Portuguese building materials as well as tests of radon barrier materials (namely bituminous materials).

Mapping and measurement (Figure 1)

Based on the totality of the questionnaires obtained during our indoor radon national survey (1989-1992) a digital database was accomplished. From the 4,200 individual questionnaires a total of 3,400 containing the most precise data (localities, level, ventilation type, etc.) were considered and re-interpreted.

The indoor radon data 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 (Table 1).

Reinforced indoor radon measurements are in course in some municipalities, mainly situated in radon-affected areas, in order to fill blank areas and improve the quality of indoor radon risk mapping.

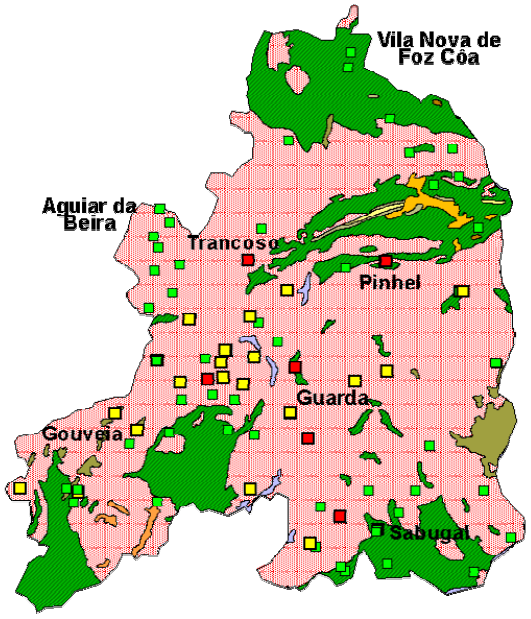


Figure 1 – Geological background and indoor radon measurements in Guarda region (■<200; 200<■<400; ■>400 Bq m^{-3}).

Table 1 – Indoor Radon statistic parameters related with different geological backgrounds

	Granitoids	Metamor.	Vulcanic	Sediment.
Median	72	31	39	21
Maximum	1751	878	304	380
# Samples	1404	876	21	1011

Published, accepted or in press work

1. M.C. Faísca, F.P. Carvalho, Evaluation of the exposure to radon in a SPA, *Book of Abstracts of the Seventh International Symposium of Natural Radiation Environment (NRE-VII), Rhodes, Greece, 20-24 May*, J.P. Mc Laughlin, S.E. Simopoulos, F. Steinhäusler (Eds.), National Technical University of Athens (2002) pp. 105.

2. P.M. Duarte, M.C. Faísca, C. Calado, The use of radon exhalation in hydrogeology – a case study, *Book of Abstracts of the Seventh International Symposium of Natural Radiation Environment (NRE-VII), Rhodes, Greece, 20-24 May*, J.P. Mc Laughlin, S.E. Simopoulos, F. Steinhäusler (Eds.), National Technical University of Athens (2002) pp. 252.

3. Radão: Um gás radioactivo de origem natural. Publicação DPRSN (2002) pp.12.

Environmental Impact of the Urgeiriça Mill Tailings

M.J. Madruga, I. Faria, C. Costa

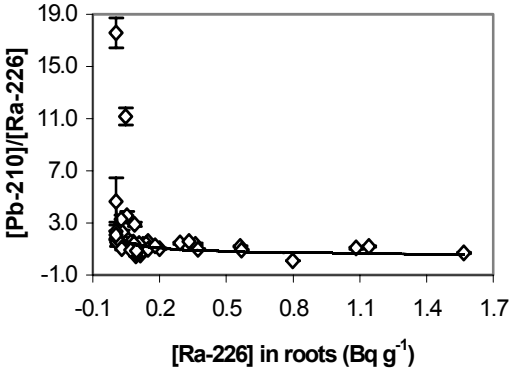
Objectives

The exploitation of the Urgeiriça uranium mining area (Viseu) has resulted in several tailing ponds, with different ages, containing solid wastes (tailings) enriched in uranium daughters, mainly ^{226}Ra and ^{210}Pb, which may be removed by mobilization processes and become available to move up the biological chain. To prevent this process, vegetation (pines, eucalyptus and native shrubs) has been made up to grow throughout the tailings. The objective of the work developed during this year is to examine the ^{210}Pb bioavailability to plants and the relationship between ^{226}Ra and ^{210}Pb in this environment.

Results

The 226Ra and 210Pb activities in solid wastes and plants (aerial parts and roots) collected at the Urgeiriça uranium mill tailings have been determined by gamma spectrometry. Results show that the frequency distribution of 226Ra and 210Pb in tailings and plants as the concentration ratios (CR) follow in general a lognormal distribution (p>0.05).

(a)



The median ^{226}Ra concentration ratios for shrubs are higher than those obtained for pines and eucalyptus. On the other hand, the median ^{210}Pb concentration ratios are of the same order of magnitude. The ^{210}Pb and ^{226}Ra relationship in pines, eucalyptus and shrubs show a lower mobility and transfer of ^{210}Pb from the tailings to the plants when compared to the radium. The ^{210}Pb/^{226}Ra activity ratios decrease at lower radium concentrations in the tailings approaching to constant values for higher radium concentrations (ex. Figure 1).

(b)

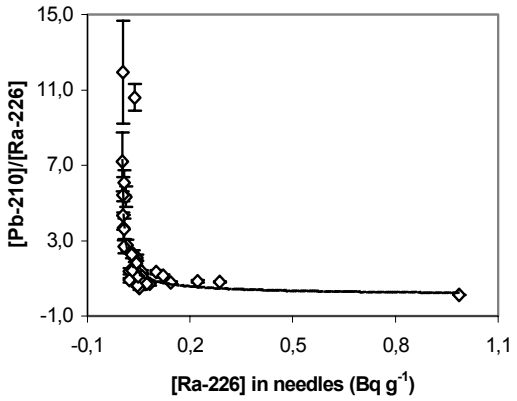


Figure 1- ^{210}Pb/^{226}Ra activity ratios versus ^{226}Ra concentrations in roots (a) and needles (b) for pines.

Published, accepted or in press work

1. M.J. Madruga, I. Faria, A. Brogueira, ^{210}Pb bioavailability to plants at uranium mill tailings. *Proceedings of the International Conference on Radioactivity in the Environment, Monaco*, 1-5 September 2002.

2. M.J. Madruga, I. Faria, A. Brogueira, ^{226}Ra and ^{210}Pb relationship in solid wastes and plants at uranium mill tailings. *Proceedings of the European IRPA Congress 2002*, Florence, Italy, 8-11 October 2002.

Development and Application of Liquid Scintillation Counting Technique to Gross Alpha, Gross Beta and Radon Measurements in Waters

I. Lopes[1], M. J. Madruga, F.P. Carvalho

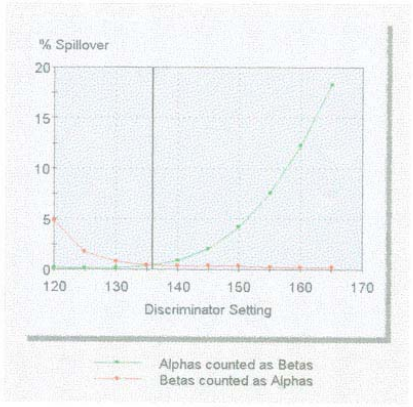
Objectives

Following the Portuguese law of the drinking water quality (Decree-law nº 243/ 2001) the evaluation of radioactivity levels in these waters requires the measurement of alpha and beta emitters. Besides, ground and surface waters may also contain elevated levels of ^{226}Ra and ^{222}Rn.

The main goal is to develop, test and optimise new radiometric techniques for the determination of these radiological parameters. These new techniques intend to process a great number of samples, in short time-consuming, and obtain accuracy results with low-level detection.

Results

New liquid scintillation counter (Tri-Carb 3170 TR/ SL) was tested for measuring gross alpha and beta activity in drinking water samples. The counter have the hability to discriminate between alpha and beta particles by pulse-shape discrimination (PSD), also called pulse-shape analysis (PSA), which allow the simultaneous measurements of both alpha and beta emitters. The optimisation of PSA was done by scanning the PSA level, with a pure α emitter (^{241}Am) and a pure β (^{36}Cl), as illustrate in the figure 1. The counting efficiencies were obtained with ^{241}Am and ^{90}Sr standards, prepared as the same way as the samples water. The tests were performed with Ultima Gold AB cocktail, in glass-vials and the measurements were carried out at 20ºC. High counting efficiencies (>90%) and lower limits detection were obtained for alpha and beta emitters. In order to test the validity of the proposed method several tap water samples were spiked with ^{241}Am and ^{90}Sr. The experimental results showed that the activities measured were in agreement to the know activities. The application of the LSC technique for determination of radioactivity of a water sample on intercomparison exercise with other international laboratories, showed that this method is suitable for determination of gross alpha and beta activities in water samples in routine work.



Setting	Alpha % Spillover	Beta %Spillover
136	0.41	0.40
136	0.41	0.40

Figure 1

Liquid scintillation technique was also tested for measuring radon level in water samples. This technique combines the advantages of minimal sample preparation time, small sample size and high sensitivity. The counter was calibrated with ^{226}Ra standard solutions, measured one month after and corrected to correspond secular equilibrium of ^{226}Ra with ^{222}Rn. The experimental efficiency obtained was closer to theoretical maximum expected (500%) for the 3 alphas and 2 betas emitters. Figure 2 shows a typical liquid scintillation spectrum of ^{222}Rn in water standard.

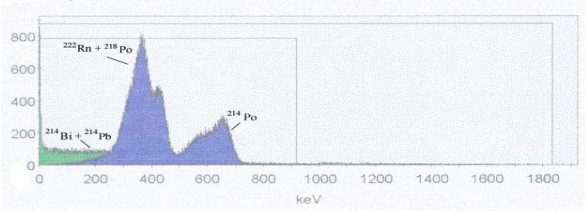


Figure 2

[1] Post-Doc student, FCT.

Contamination from Anthropogenic Origin in Coastal Lagoons and Coastal Areas[(a)]

F.P. Carvalho, J.M. Oliveira, J.-P. Villeneuve[1], A. Lucas

Objectives

To investigate the current levels of contaminants and deposition in sediments of environmentally-persistent contaminants from anthropogenic origin in tropical coastal lagoons. Application of radionuclide based techniques to investigate the fate of non-nuclear contaminants.

Results

Analyses of persistent organic pollutants (POPs) were performed in sediment layers of cores from coastal lagoons and estuaries in Mexico and Brazil. POPs, as well as radionuclides were measured in mussels, oysters and fish from these areas also. In particular, the naturally occurring ^{210}Pb was measured in sediment layers from tube cores from the bottom of lagoons to apply a sediment chronology method and date the past deposition of contaminants. The more persistent residues of organic contaminants, such as PCBs and DDTs, are present in old sediment layers with little degradation. It was concluded also that toxaphene, a persistent organochlorine compound, is very recalcitrant to degradation and may persist decades in sediments. All these contaminants were present in the estuarine coastal environment investigated in the tropics, but they are also present in coastal environments of Europe due to past use of these compounds. The outcome of this collaborative research, including data on organic contaminants and radionuclides, will be merged in an international symposium to be organized next year.

Investigation on transuranic levels in the coastal marine environment in the Portuguese coast is under way.

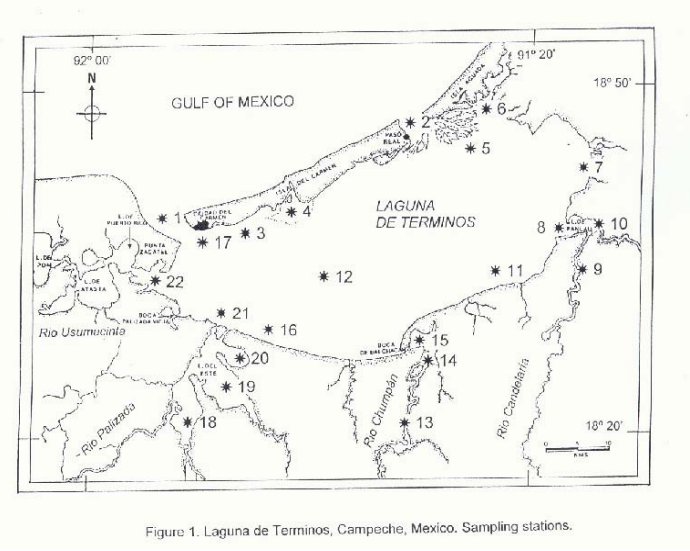


Figure 1. Laguna de Terminos, Campeche, Mexico. Sampling stations.

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[1] IAEA, Marine Environment Laboratory, Monaco.

(a) In collaboration with University of Coimbra, University of Bahia, Brazil, and University of Campeche, Mexico.

Assessment of the Radioactivity in the Tagus Estuary due to Hospital Discharges[1]

F.P. Carvalho, J.M. Oliveira, J.M. Gouveia, A. Libânio

Objectives

To assess the radioactive contamination of the estuarine environment due to discharges of liquid effluents containing radioisotopes from use in hospitals.

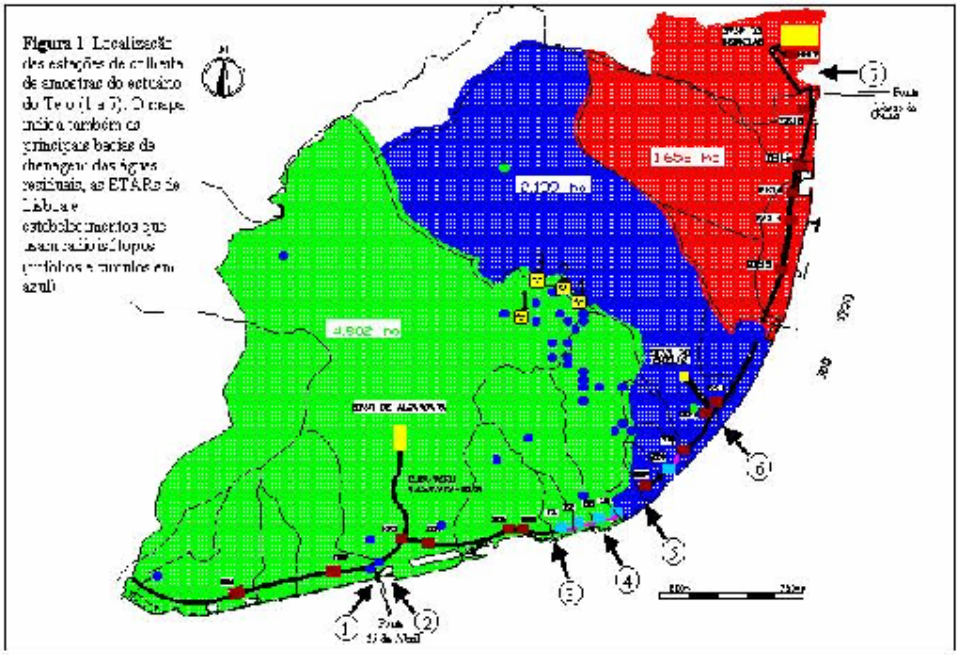
Results

The municipality of Lisbon manages the sewers system and the waste water treatment plants of the city. In Lisbon there are about 40 medical establishments that use radioisotopes in nuclear medicine activities. All of them, public and private, are connected to the sewers system of the city and discharge liquid effluents eventually containing radioactive susbtances. The municipal authorites have expressed concern about these discharges and requested our collaboration to assess the contamination and radiological risk resulting from the discharges. The survey was extended from the sewage system to encompass the Tagus estuary because the estuary is the final water body receiving the domestic effluents from the city, both the ones that are treated in waste water treatment plants as well as the untreated ones.

During the year 2002, the investigation focused the area close to the North bank of the estuary. Four sampling compaigns were performed to collect water, mussels, sediment and fish.

Iodine-131 and Technecium-99m were several times detected in water and mussel samples, although generally in low concentrations.

This work will be continued during the next year to perform a radiological risk assessment.



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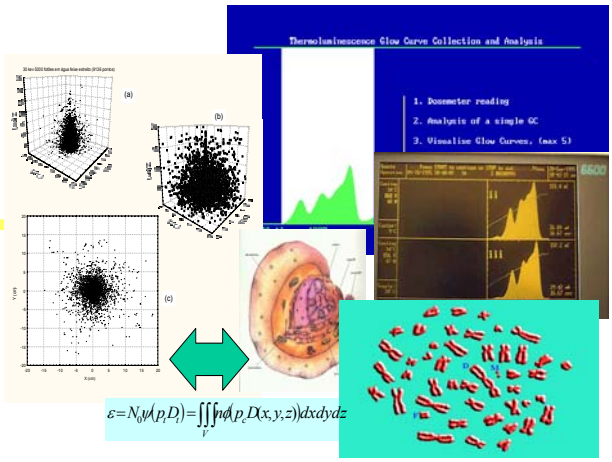
[1] With the collaboration of Câmara Municipal de Lisboa

Division of Dosimetry, Radiological Safety and Biological Effects of Ionising Radiations



Division of Dosimetry, Radiological Safety and Biological Effects of Ionising Radiations

Fernando P.Carvalho

This Division has been a provisional structure arrangement, that in the future will be reformulated in a more functional way. Nevertheless, the various groups included in the Division are a mainstay for a coherent radiation protection infrastructure.

The country still needs to build up such a system. For this aim, advice and support have been provided by the IAEA, the Article 35 Verification Mission (Euratom Treaty), international radiation protection experts and even the ITN Advisory Board members in their reports. Some of the essential "parts" for such a system are the groups in this Division.

The report of their research and technical activities give account of the excellent work in upgrading individual dosimetry, improving quality control and providing now to the country a National Registry of Doses.

Assessment of safety in radiological facilities is essential for the safe use of ionizing radiation in peaceful applications, including medical, industrial and research applications. A steady effort has been made to train new staff to reinforce the team and allow for expansion of activities into internal dosimetry using a whole body counter. Furthermore, the use of Monte Carlo codes to model the transport of energy at sub cellular levels is a development to supplement macroscopic dosimetry and predict radiation damage at microscopic scale.

Radiobiology and research on the effects of ionising radiation is also a key area in radiation protection. A Doctoral thesis is in preparation, and application of the know-how in this area is now foreseen in an un precedent scale in the framework of a national project for the investigation of effects of uranium mining in the population.

Support to the Implementation of a Radiation Protection System in Portugal

F.P. Carvalho, M.B. Martins, J.G. Alves

Objectives

Portugal stays far behind the adoption of the International Basic Safety Standards in Radiation Protection of workers and the public. There are European Directives to be transposed to the National Law and recommendations from international organizations to build up a radiation protection system with an independent authority.

The DPRSN participates in an European regional project set up by the AIEA (RER/9/062) to improve the current situation and to enhance awareness of public administration on radiation protection and safety recommendations.

Results

In the framework of this project we took part in IAEA regional meetings to discuss the radiological protection infrastructures existing in Member States, as well as to identify the gaps and needs for IAEA assistance. Part of this effort is also directed to enhance the safety and security of radiation sources worldwide.

A national protection system, as agreed at international level, is made up with several components: coeherent laws and regulations, technical infrastructures to measure radiation and radioactivity, to ensure an individual dosimetry and to control radiation sources, the registry of sources and radiation doses, and an independent regulatory authority.

Portugal is one of the few countries in western Europe that lacks suitable radiation protection infrastructures in place. Upcoming new members of the European Union, from Eastern Europe, have wisely used the IAEA support to organize there own radiation protection infrastructure and are now better prepared than Portugal to comply with safety rules and EU Directives.

During 2002, an IAEA Peer Review mission of experts, aimed at assessing the existing national legal and technical infrastructures in radiation protection and nuclear safety in order to provide advice to the country, had been planned. This mission was postponed several times at the request of ITN and did not take place.

In the framework of this IAEA supported activities, several ITN fellows and staff from radiological services of Hospitals were awarded with fellowships and could attend specialized training courses abroad. Three national training courses on radiation protection were organized by DPRSN and provided to industry workers.

Following requests from the Ministry of Science and Technology, intensive collaboration in technical issues was also provided by DPRSN, in the transposition of EU Directives into the national legislation.

Optimization of the DPRSN TLD-Individual Monitoring System

J.G. Alves, V.I. Batel[1], P.B. Silva, O. Margo, R. Barbosa and A. Delgado[2]

Objectives

The main objective is to improve the routine work of the Individual Monitoring Service based on thermoluminescence dosimetry (TLD).

To achieve this goal four objectives have been established: 1. Implementation of methods for the continuous evaluation and analysis of quality control (QC) parameters; 2. General improvement of the working conditions; 3. Evaluation of the system's performance using a simpler and faster reading cycle; 4. Accreditation of the service by IPQ-Instituto Português da Qualidade.

Results

1. Since Sep.-2000 some tests have been routinely implemented to test the system's performance and for the simultaneous determination of important QA/QC paramenters[1,2]. Figure 1 presents the limits of detection obtained as proposed by Hirning (Health Phys. 62(3), 1992), from Sep-00 until Jul-02.

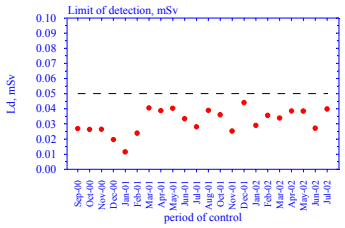


Fig. 1 – Limit of detection: evolution Sep00-Jul02.

Sensitivity changes influencing the response of the TLD system and the dose evaluation method are being evaluated. Type testing using radiation qualities and phantoms described in the ISO 4037 are being performed along with an evaluation of the overall uncertainty. QC charts with defined acceptance, action and rejection levels are being prepared.

2. The working conditions at the Service are improving since the beguining of 2002. The area allocated to the service was slightly increased and walls were moved so that new areas could be defined. The TL readers, two Harshaw 6600 automatic readers and a 4500 manual reader, with the corresponding online computers and server, were moved into a dedicated area where a new bench was put in place with N_2 supply for the three readers, air conditioning and air extraction. An UPS was installed so that in case of a power failure, the TL-readers will finish the reading cycle, store the reading on the computer and on the server, allowing enough time for manual shutdown. New offices were created for administrative tasks such as orders, contracts, forms and payments, and for either monitoring period with the respective computers, dosemeters' storage, files and records of each monitored installation.

A new reading software (Win-Rems®) for the control of the cycles, evaluation and storage of the individual sensitivity factors, reader calibration, dose evaluation, etc is being installed. This software is an upgrade of Net-Rems®, which was working since 1995. Computers were installed in a dedicated network closed to the outside. The two home developed databases used for the monitoring of approx. 7,000 workers and their individual doses periodically evaluated at the service, were converted to a recent version of Access® and are presently running under Win-xp® on UPS protected and isolated computers.

The nitrogen supply to the reding devices evolved from a four-bottle manually carried system located inside the building, to a unit composed of a "ranger" (10-12 bottles equivalent) linked to the former system and located in the outside of the building. A higher autonomy of the service relative to the gas supply was attained, requiring less manual intervention and granting easier replacements.

3. The system's performance is presently being tested with a new reading cycle. The improvement consists in avoiding the time consuming pre-heat of 10sec at 130ºC in every run, using a linear reading cycle. The collected glow curves (GC) are then sent by e-mail to CIEMAT for evaluation using the simplified GC analysis methods. Calibration and user GCs are presently being obtained for testing.

4. All the important procedures followed in routine work are to be written down in order to prepare the necessary items for the accreditation of the service by IPQ-Instituto Português de Qualidade.

Published, accepted or in press work

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[1] MSc student, at Hospital de Santa Maria, Serviço de Radioterapia, Av. Prof Egas Moniz, 1649-035 Lisboa
[2] CIEMAT – Dosimetria de Radiaciones, Av. Complutense 22, 28040 Madrid, Spain

Calibration of the Film Dosimeter NRPB/AERE

A.F. Carvalho, J.G. Alves, A. Roda[1], L. Santos, J. Cardoso

Objectives

The main objective of this work is to perform the calibration of the whole body NRPB/AERE dosemeter with the purpose of monitoring individuals occupationally exposed to external X and gamma radiation. The dosimeter is to be worn on the trunk, in the position of likely maximum exposure.

Results

The Film Dosimeter using the Eastman Kodak type 2 film detector and the NRPB/AERE holder allows the evaluation of occupational radiation doses with energies in the interval 15 KeV to 3 MeV.

At DPRSN there are about 3500 NRPB/AERE holders available to be used in the future by the Film Dosimetry Service for the individual monitoring of professionally exposed workers.

This work is being carried out in collaboration with the Standard Dosimetry Laboratory of DPRSN.

The calibration process started by performing several preliminary tests to estimate uncertainties associated with the chemical processing namely:

1) For practical purposes the chemical reagents concentration to be used in film developing are 7,9L of reagent to 40L of solution.

2) The deviation in the net optical density readings were not measurable for films processed in slightly (±1L water) different concentrations.

3) Deviations observed in the net optical density readings dependent on the developer parameters (time, temperature and aging) for a routine control procedure were lowering the stochastic uncertainty of the process.

Concerning the densitometer, the selection of the 1.0 optical density calibration filter taking its value at 550 nm (1,028) was based on a densitometer calibration curve and a compromise between the stability of the calibration value and the filter's dependence on the wavelength of the transmitted light. No corrections were found to be necessary.

Concerning the dimension of the sample a decision of a minimum of 4 irradiated dosimeters per dose for high doses up to a maximum of 8 for low doses was based in the analysis of the standard deviations of several sample sizes and taking into account an optimization of economical/time consuming aspects.

The characteristic curve of the emulsion was calculated expressing the exposure in terms of air kerma for gamma radiation of ^{137}Cs and the optical density measured under the most heavily filtered area of the film. Dosemeters were irradiated in groups of two for absorbed doses in air ranging from 0.05mGy up to 1Gy and the results are plotted in figure1.

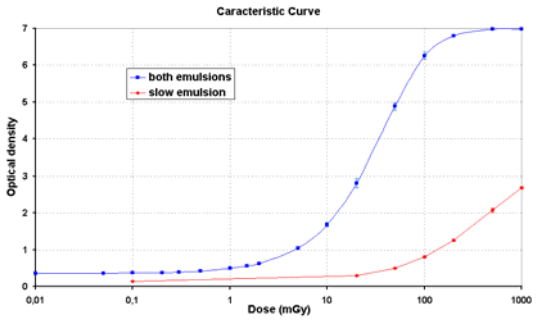

Fig.1 – Caracteristic curve for NRPB/AERE dosimeter ploted on a logarithmic scale.

To determine the calibration curves for gamma photons, the dosemeters were irradiated in groups of four, geometrically centred on the surface of a 30×30×15 phantom consisting of a skin PMMA thickness filled with water, placed 2 m away from the ^{137}Cs source, completely inside the radiation field. Using the appropriate conversion coefficients (ISO4037-3) to convert the photon flow of the beam to the dose at the surface of the phantom, we estimated the personal dose equivalent at the depth of 10mm, $H_P(10)$ according to the technical recommendations published by the Radiation Protection 73.

Net optical densities were plotted against $H_P(10)$ to obtain gamma calibration points. Adjustment of the points to a curve lead to an estimation of two quadratic polynomials for the intervals]0; 2]mSv and]2; 15[mSv and a third degree polynomial for the interval [15;100]mSv. For higher doses data are not yet available. Tests are being performed to evaluate the accuracy of these curves.

[1] MSc Student

Radiobiology and Dosimetry by Cytogenetic Methods

J.H. Pereira Luís, M. Luísa Pedro, M.J.S. Silva, R.G.V. Vieira and P.A.M. Cardoso

Objectives

Study the biological effects of low level ionizing radiation and evaluation of the genotoxic damage as a result of exposure to ionizing radiation in professionally exposed workers and in the case of accidents.

Results

Using cytogenetic methods and chromosomal aberration analysis, we did studies of low level radiation in professionally exposed workers. As a consequence of the exposure to ionizing radiation, to this individuals late biological effects may arise.

Fig.1 Metaphase of a normal cell.

Among the most serious late effects is the cancerigenesis. Experimental studies show that radiation leads to genotoxic lesions, DNA instability and chromosomic breaks and mutations. It is generally accepted that chromosomal mutations are causal events in the development of neoplasia, and it has been postulated that increased chromosomal damage may reflect an enhanced cancer risk. Recent works show the existence of a relation between chromosomal aberrations frequency and cancer incidence. Therefore, an analysis of cytogenetic damage in peripheral blood lymphocytes, at the individual level, may indicate the degree of stress that the individual genome is submitted to, as well as its risks in the development of cancer. In order to evaluate genotoxic risks due to exposure to ionizing radiation in a group of professionally exposed workers and in some cases of accidents, the frequency of several genotoxic aggression cytogenetic biomarkers has been studied.

Fig.2 Metaphase cell, from peripheral blood lymphocytes of an individual accidentally exposed, with chromosomal damage showing chromosome breaks and chromosomal recombination forming dicentrics.

On individuals with anomalous results of chromosomal aberrations and of sister-chromatid exchanges (SCE), was putted the hypothesis that they might have their capacity to repair radiation damage decreased owing to the environmental exposure to ionizing radiation. The challenge assay was used to detect abnormal DNA responses in those susceptible individuals. It was verified that in the workers' lymphocytes, the chromosomes presented a significant increase of chromosomal aberrations, comparatively with the ones of the control. On some individuals we also studied apoptosis by the DNA internucleosomal fragmentation method. The apoptosis and the necrosis dose effect was evaluated after γ irradiation.

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Methylene-tetrahydrofolate reductase C677T polymorphism in thyroid cancer

O.M.Gil, J.Gaspar[1], B.Cordeiro[1], J.Rueff[1]

Objectives

5-Methylene-tetrahydrofolate reductase (MTHFR) is a key enzyme in folate metabolism. This enzyme plays a central role in the provision of methylgroups to the metabolism, via S-Adenosyl-Methionine (SAM) production, the methyl donor required for DNA methylation.

Significant alterations on the activity of this enzyme could lead to alterations in the synthesis of dTMP involved in the DNA synthesis pathway. A *MTHFR* polymorphism located at nucleotide 677(C⇒T) leads to an alanine to valine substitution resulting in a decreased enzymatic activity and higher thermolability. This polymorphism has been associated with several human tumours. Aberrant DNA methylation has been described as an early event in thyroid carcinogenesis.

In the present study we investigate, the potential association of a common C677T polymorphism in the *MTHFR* gene, wich result in reduced enzyme activity *in vitro* and affects DNA methylationin, with individual susceptibility to thyroid cancer using a PCR/RFLP based methodology.

(with no thyroid pathology) were from São Francisco Xavier Hospital

The results obtained show that the frequency of *MTHFR* C677T polymorphism is not significantly different for all the cases studied when compared with control populations and do not support the association of *MTHFR* C677T polymorphism and thyroid cancer risk. However we can not rule out that other *MTHFR* polymorphism and/or polymorphism in other genes associated with the metabolic pathway of folate could alone, or in association, be involved in the individual susceptibility for this pathology.

Results

Thyroid cancer patients (103) were from the Nuclear Medicine Department of the Portuguese Oncology Institute of Lisbon, and case control population (161).

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[1] Dep. de Genética, Universidade Nova de Lisboa.

Synthesis, characterization and biodistribution of ^{153}Sm, ^{166}Ho and ^{177}Lu-phosphonates, glycoproteins and glycolipids

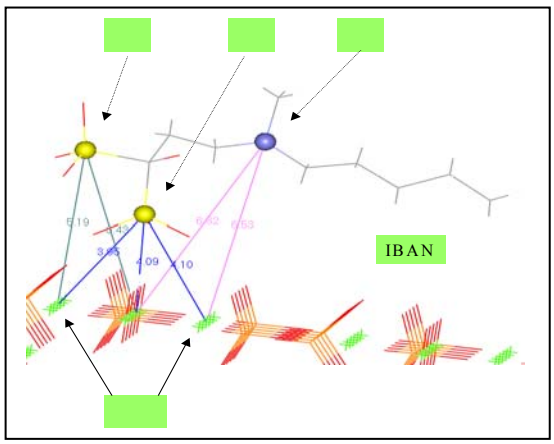
M. Neves, H. Raminhos, A. Kling[1], L. Gano[2], M.C Costa[3], M.R. Costa[3], F. Teixeira[3], M. Chandia[4], M. Rosado[5], R. Fausto[5], C. Geraldes[6], M.I. Prata[6], A.C.Santos[7], J.J.P. Lima[7]

Objectives

The aim of this project, is the synthesis, characterization and evaluation of phosphonates, DTPA derivatives and glicoproteins labelled with radiolanthanides as new radiotherapeutic agents. The design of new ligands is performed by molecular modeling computational studies.

Results

A direct correlation could be established between Coulomb interactions energies and in vitro bisphosphonates (pamidronate, alendronate, neridronate, olpadronate and ibandronate) affinity towards hydroxyapatite (bone mineral component) and the described bone resorption inhibition. Also, biodistribution studies have shown a good correlation between bone uptake and bone resorption inhibition. A new class of bisphosphonates, indazolbisphosphonates were synthetized and characterized. The figure shows ibandronate as an example of computational simulation molecular interactions with hydroxyaptite. Electrostatic energies were calculated from atomic interdistances.



Published, accepted or in press work

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[1] ITN-Reactor Sector
[2] ITN-Chemistry Sector
[3] INETI – Lisboa, Portugal
[4]Centro Nuclear la Reina, Santiago do Chile, Chile
[5]Department of Chemistry, University of Coimbra, Portugal
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[7]IBILI, University of Coimbra, Portugal

Division of Metrology of Ionising Radiations

Division of Metrology of Ionising Radiations

António M. Ferro de Carvalho

The metrology of ionizing radiations and radioactivity comprises activities in the following areas.

- Research and training in metrology of ionizing radiations;
- Maintenance of national standards of measurements, under a protocol with the Portuguese Institute for Quality;
- International cooperation with EUROMET, IAEA, WHO and EA in the field of interlaboratory comparison of standards and measurements;
- Collaboration and support of other research groups performing measurements or irradiations;
- Services of metrological control – type testing and calibrations – of measuring instruments, according to national regulation (Portaria 423/98).

In 2002 as a national metrology laboratory we proceed with activities to implement the international Mutual Recognition Agreement (MRA) of national measurement standards and of calibration and measurement certificates.

The list of Capacity of Measurement Services – including ITN services - was approved by EUROMET and is being evaluated by other regional metrological organisations (Asia and America).

The MRA is being implemented between Metre Convention Member States.

The Quality System of each laboratory participating in the Mutual Recognition Agreement (MRA) should be implemented as an additional requirement.

The MRA places considerable emphasis on the adoption of ISO 17025 by participating laboratories. To reply to this requirement EUROMET set up the Project 512 called QS-Forum. Therefore the aim of QS-Forum is to ensure that there is a common understanding in Europe of the requirements of ISO 17025 and its application by national metrology laboratories.

The Quality System of LMRI it was described and approved in a 2002 Forum meeting. Some additional documents should be prepared, but all the requirements should be finished until June of next year.

An internal audit of the Quality System is being prepared to be carried out in January of 2003.

Technical support was provided to 4 students that used laboratory capabilities to carry out experimental work for their PhD and MSc theses.

Irradiation and measurement of doses were performed for 2 research teams from outside ITN.

Intercomparisons of doses at radiotherapy and radiation protection levels were done in programmes run by IAEA/WHO, IAEA and EA.

Calibration services were provided for industry, universities, hospitals, armed forces, and departments of ITN.

Mutual Recognition of Calibration and Measurement Certificates Quality System

A.F.Carvalho, L.Santos, J.Cardoso

Objectives

Directors of the national metrology institutes from Member States of the Metre Convention signed a Mutual Recognition Arrangement with the following objectives:

- to establish the degree of equivalence of national measurement standards;
- to provide for the mutual recognition of calibration and measurement certificates;
- to provide governments and other parties with a secure technical foundation for wider agreements related to international trade and regulatory affairs.

The process is based in international comparisons of measurements, implementation of quality systems and demonstration of competence.

The Metrology Laboratory of Ionising Radiation of ITN/DPRSN – maintaining the national measurement standards under a contract with the Portuguese Institute for Quality – joined that arrangement and the EUROMET projects for their implementation.

Results

LMRI stated its capabilities for calibration and measurements in the field of dosimetry of ionising radiation. These capabilities cover 43 services. After discussion between participating national metrology laboratories the statement of our capabilities was approved by EUROMET. Statements of the measurement capabilities of each national metrology laboratory will be introduced in a database maintained by the BIPM and publicly available on the Web.

In 2002 services capabilities of each regional metrological organisation – Europe, Asia and America - were evaluated for mutual acceptance.

One of the requirements of the mutual recognition arrangement is that the national metrology laboratories shall maintain an operational quality system (QS). EUROMET project 512 was devoted to preparing the implementation of QS in the national laboratories. LMRI is participating in that project that is being coordinated at national level by Portuguese Institute for Quality (IPQ).

Reconnaissance mutuelle
des étalons nationaux de mesure
et des certificats d'étalonnage et de mesurage
émis par les laboratoires nationaux de métrologie

Paris, le 14 octobre 1999

Mutual recognition
of national measurement standards
and of calibration and measurement certificates
issued by national metrology institutes

Paris, 14 October 1999

Comité international des poids et mesures

Bureau international des poids et mesures

Organisation intergouvernementale de la Convention du Mètre

Dose calculations for Radiosurgery and Intracoronary brachytherapy

C. Oliveira, A. Chaves[1], M.C. Lopes[1], H. Yoriyaz[2]

Objectives

The objectives of this project are:

1. To understand the details of basic dosimetry for narrow beams, originated in radiosurgery, such as the behaviour of the point of maximum dose, d_{max}, using Monte Carlo simulations.

2. Calculations of dose distributions in the artery wall and in healthy tissue during intracoronary brachytherapy treatments.

Results

1. The depth of maximum dose, $d_{max,}$ increases as the size of the additional collimators increases for narrow photons beams used in Radiosurgery (1). This phenomenon is in opposite way from what it is observed in conventional Radiotherapy photon beams. Photons that have no interaction in the additional collimators are the responsible to the shift of d_{max} for narrow photon beams. Monte Carlo simulations in water have shown that electrons that reach the central axis originated by photon collisions can be divided into two groups. Some electrons were originated far way from the central axis and can deposit dose deeper from their point of origin. But some electrons can deposit dose locally because they were originated very close from the central axis. It was demonstrated that these electrons also contributes to the effect of d_{max}.

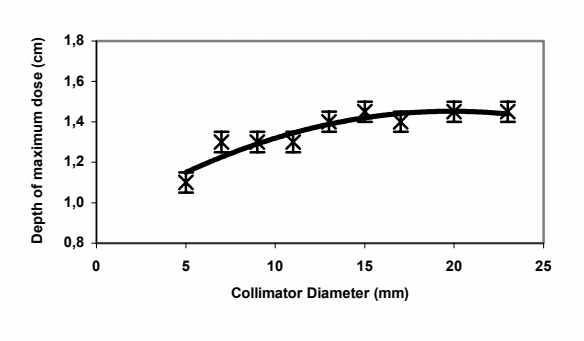

Fig.1 – Dependence of the depth of the point of maximum dose with the size of the additional collimators. (Simulation results).

2. Intracoronary brachytherapy prevent neointimal proliferation after procedures such as coronary angioplasty. Dosimetry is very important for these procedures but measurements are difficult to be done. Monte Carlo calculations were performed.

Special attention was put in some situations: displacement of the radiation source from the centre; perturbation in the dose due to a calcified plaque; perturbation in the dose due to a stent.

The observed shadow effect of the stent will tend to increase as the source energy decrease or/and the thickness of the stent increase (2). The studied case has been for the ^{90}Y source and the minimum dose has a decrease of 15%. The study of the effect of not centered sources allows conclude that one should be very careful using some beta source due to the dose perturbation factor which can be rather high. The dose distributions in the calcified plaque are quite different for beta sources or for gamma source (2). For these latter sources the dose for distances larger than the plaque thickness tends rapidly to the dose values obtained without plaque.

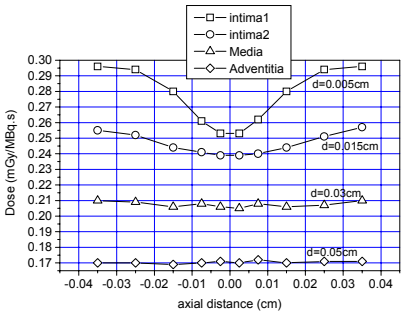

Fig. 2 -Dose Perturbation Factor due to ring stents (^{90}Y source).

Published, accepted or in press work

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2. C. Oliveira, Quantificação dos problemas de protecção radiológica no doente sujeito a braquiterapia intravascular com base em cálculos de Monte Carlo *IX Jornadas Portuguesas de Protecção contra a radiação*. Lisboa, Nov. (2002).

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[2] IPEN - S. Paulo, Brasil

Division of Operational Radiological Protection and Radioactive Waste Management

Division of Operational Radiological Protection and Radioactive Waste Management

Romão Trindade

The Operational Radiological Protection and Radioactive Waste Management Service (SPROeGRR) continued the development of the activities that have been mentioned in the previous Annual Report.

It is clear that all the activities of the Group are heavily characterized by their component of public utility services, based on the fulfillment of the legal aspects related to them. Indeed, these activities for the Community are, in Portugal, exclusively carried out by the SPROeGRR.

The radioactive waste management activities in the National territory meaning, the collection, segregation and treatment for interim storage at the Radioactive Waste Pavilion, are regulated by Decree-Law nº 311/98 of Ministry for Science and Technology, Ministerial Order nº 7714/2002 (2ª Série) and Decree-Law nº 165/2002 of Ministry for Health. About 130 requests for radioactive waste collection including spent sealed sources were received during 2002.

The licensing of sealed sources for industrial, research, medical or other application, are regulated by Decree-Law nº 153/96 of Ministry of Enviroment and Decree-Law nº 165/2002 of Ministry for Health. Several processes were thoroughly analyzed by the Group staff and 191 licenses were issued in the current year. More processes are still being analysed.

The detection of contaminated and activated materials or even radioactive sources in scrap metal or any other material where, legally, they should not exist was another of the activities developed in the last year. The most important measure to prevent entry of uncontrolled contaminated material in the metal scrap stream is to ensure adequate control over the materials resulting from activities using radioactive materials. The importance of the situation is recognized by the EC and IAEA.

The transport of radioactive materials has being another of the activities of the Group. The monitoring of radioactive cargo transported in containers by commercial ships that called at Portuguese harbors, are different situations that usually happening during the year.

The radiological control and the intervention in case of radiological incident or accident by monitoring the contaminated or irradiated areas, personnel and equipment are also activities of the Group. The intervention of the Group ranges from monitoring the situation to the application of all the adequate procedures to solve it, advising the clients about the rules and their application in order to avoid future incidents or accidents. Even in cases where materials are not supposed to be radioactive or contaminated, the Group has been called to intervene in order to clarify the absence of any contamination and make sure that those materials are safe to export.

In this last year and due to a heavy load of services to the Community, it was impossible to develop research activities. However, it should be pointed out the fact that the members of this Group have been invited to join the following projects: "*Radioactive Waste Vitrification*" (coordinated by ITN/ Chemistry Department); "*Speciation Studies of Radioactive Elements (actinides and fission products) by electrospray ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (ESI-TICR/MS)*" (coordinated by ITN/Chemistry Department); "*Mass Spectrometry Network for Molecular and Biomolecular Analysis*" (coordinated by ITN/Chemistry Department); "*Upgrading of Radiation Technology Unit"* (coordinated by ITN/UTR); "*Ambiágua – The Environment and The Water"*(coordinated by Environmental Biology Center of Lisbon Faculty of Sciences).

The SPROeGRR is involved in the following Technical Committees: *Advisory Committee for Programme Management of Commmunity Plan of Action in the Field of Radioactive Waste* (ACPM); *European Waste Regulator Forum* (EWRF); *Standing Working Group on Safe Transport of Radioactive Materials* (TRAM); *National Committee for Transport of Dangerous Goods* (CNTMP); *Net Enabled Waste Mangement Database* (NEWMDB); *Radioactive Substances Committee of Oslo and Paris Convention (OSPAR);*

Radioactive Waste Management Committee, RWMC, (OECD). Related to the latter, the report " *Implementation of the OSPAR Strategy with Regard to Radioactive Substances*" was elaborated and presented to the OSPARCOM.

This Group has also participated with comments for the "*Proposal for a Council Directive on the control of high activity sealed radioactive sources*", "*Council Resolution on the establishment of national systems for surveillance and control of the presence of radioactive materials in the recycling of metallic materials in the Member States*", "*Draft prorposal for a Council Directive on the management of spent fuel and radioactive waste*" and "*European Agreement concerning the International Carriage of Dangerous Goods by Road -ADR restructured*".

The SPROeGRR also developed an intensive contact with all the clients in the different fields, explained what is required by Law, sending all the important paper work such as legislation, technical requirements, practical procedures and administrative steps as well as clarifying any doubts that might arise. This work is of paramount importance for the conclusion of the processes mainly in the cases of radioactive wastes and sealed sources but also in all the other fields of intervention.

Services

I. Division of Environmental Radioactivity

1. Radioactivity in Drinking Waters

G. Ferrador, M.M. Sequeira, V. Silvino, M.A.Tavares, M.A. Pereira, M.J. Madruga

Following the Portuguese Law (Decree-Law nº243/2001) the evaluation of the radioactivity levels in public waters (human consumption) should be performed. Some water suppliers as "Empresa Pública de Águas de Lisboa-EPAL", Serviços Municipalizados de Abastecimento de Água do Porto-SMASP", "Águas do Cávado, S.A." and "Águas do Douro e Paiva, S.A." requested regularly global alpha, global beta and tritium measurements.
A total of 284, global alpha and beta, and 130 tritium measurements were performed during 2002.

2. Natural Radioactivity in Mineral Waters

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

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, global beta and ^{3}H. Several enterprises and the National Authority of the sector often request by this radiological study. A total of 35 analyses were performed during this year.

3. Artificial Radioactivity Levels in Foodstuffs and other Samples

M.J. Madruga, J. Gouveia, M.A. Gameiro, S. Curado

By request of the Direcção Geral de Fiscalização e Controlo da Qualidade Alimentar, public and private enterprises, different kind of samples, mainly food samples imported or to be exported are monitored in order to determine concentrations of artificial radionuclides (gamma spectrometry analysis, and ^{90}Sr determinations). During this year 32 samples were analysed.

4. Natural Radioactivity and Radon Exhalation from Building Materials

P.M. Duarte, L. Machado

By request or collaboration with private enterprises or users, 12 building materials were analysed in order to evaluate their natural radioactivity.

5. Indoor Radon

P.M. Duarte, L. Machado

By request of public and private entreprises indoor radon measurements were performed in buildings. A total of 57 analyses were performed during this year.

6. Application of Radon Exhalation in Hydrogeology

M.C. Faísca, P.M. Duarte

Conclusion of a study of radon exhalation, performed, under contract with the Camâra Municipal de Nisa, in order to identify favourable places to the implantation of new wells at the spring area of Fedegosa de Nisa (Alto Alentejo, Portugal) as well as to improve the knowledge about vulnerability to infiltration and transit of potential contaminants.

II. Division of Dosimetry, Radiological Safety and Biological Effects of Ionising Radiations

1. Specialized Cytogenetic Analyses

J.H.P. Luís, M.L.Pedro, M.J.S. Silva, R.G.V. Vieira and P.A.M. Cardoso

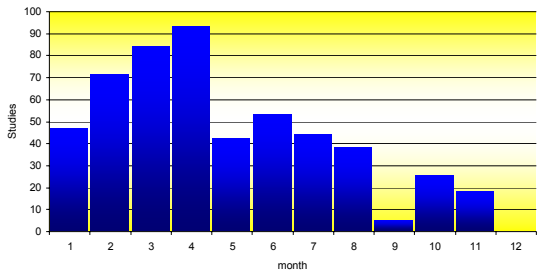
During the year 2002 several specialized cytogenetic analysis were done. The analyses were used to identify biological damage at chromosomal level induced by ionizing radiation or by other environmental aggressors. This type of analysis was also used to estimate the radiation dose by biological dosimetry.

Type of analysis	N^r analyses
Chromosome aberration	8
Sister Chromatid exchange	12
Micronucleus	2

2. Radiological Safety Assessment

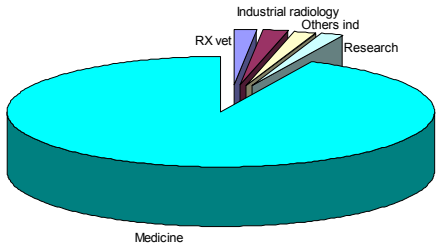
A.D. Oliveira, J.S. Jesus, K. Jacob, M. Ângelo, M.E. Pacheco

The General Directorate of Health of the Ministry of Health requested studies of radiological safety assessment of radiation facilities accordingly the Decree-law Nº 165/2002.
In the next graph we show the evolution of the number of requests by the Directorate of Health (DGS).



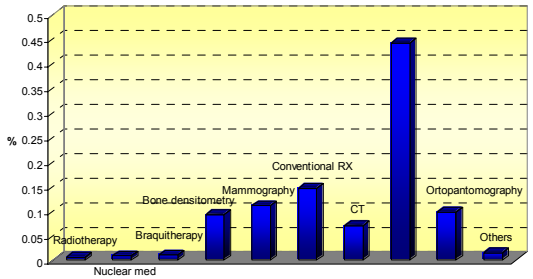
Number of request for radiological safety assessment studies by the DGS.

The December data is not included yet. The total number of request was 520, meaning a monthly average of 47. Furthermore we also made about 80 in situ inspections.



Type of radiological assessment requested

Like in the previous year the medical facilities were the bigger proportion of requests, corresponding approximately to 92% of the studies and 2% for each one of the remainders, for example industrial radiology.



Percentage of radiological safety assessment in medical facilities.

The bigger fraction of requests was in dental radiology. This fraction causes mainly an enormous increase in administrative work due to the very low risk involved.

The highlights of the current year are:

- We lost two physicists, which compromises future studies, for example in radiotherapy and PET, and the development of good research for good services.
- To have good services we need good research. It is urgent to develop further the research in the group.

Our small group has a significant production with important revenues, however the group is decreasing while the requests are increasing. The policy of the activity needs additional discussion due to the new legislation.

3. Individual Monitoring of External Radiation

The main aim of individual monitoring is the measurement of the occupational radiation doses and the compliance to the established regulations. At DPRSN there are two on-going control methodologies, film and thermoluminescence dosimetry (TLD).
In 2002, about 9,800 workers from 990 facilities were controlled on a monthly (TLD) or a quarterly basis (film dosimetry and TLD) by the Department, corresponding to approximately 54,860 assessed doses.

3.1 Film Dosimetry

M.B. Martins, G. Rangel, M.A. Gameiro, J.M. Paiva, A.R. Roda

The personal dosemeter used for the measurement of X ray and gamma radiation was the Kodak type II film inserted on a homemade holder, changed on a quarterly basis.
In 2002 about 3,000 workers (aprox.) from 270 facilities professionally exposed to ionizing radiations were controlled (fig. 1).

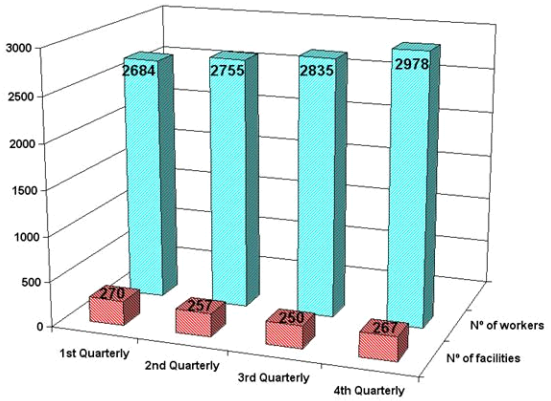


Fig. 1 – Number of workers and facilities by monitoring period.

In Figures 2 and 3 the number of monitored workers and facilities grouped by different fields of activity, namely, health, industry and research laboratories, are displayed.

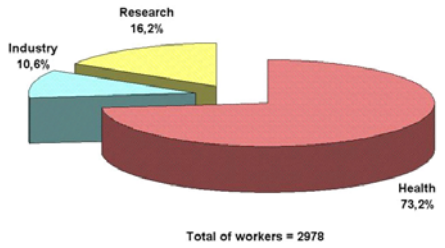


Fig. 2 - Percentage of monitored workers grouped by field of activity.

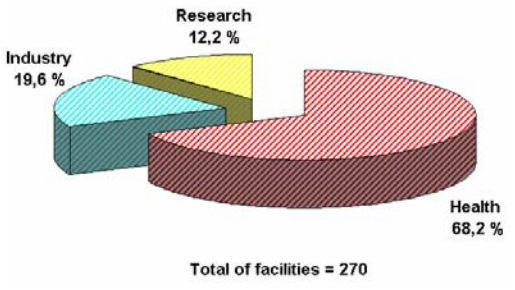


Fig. 3 – Percentage of facilities grouped by field of activity.

The distribution of the annual effective doses by dose intervals for the different fields of activity is presented in Figure. 4. It can be seen that the annual doses are distributed in two intervals E<0.5 mSv (~93%) and 0.5<=E<5 mSv (~6%). Annual doses exceeding 20 mSv were registered in less than 0,1% and the percentage of workers that received occupational doses higher than 10 mSv is approximately 0.4% of the total number of controlled workers.

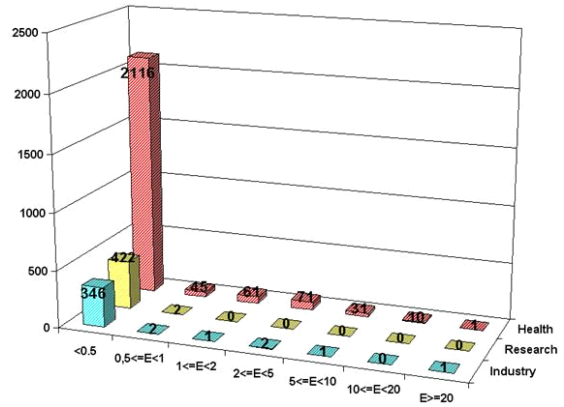


Fig. 4 – Distribution of the annual effective doses by dose intervals

3.2 Thermoluminescence dosimetry

J.G. Alves, J.V. Monteiro, O.C. Margo, P.C. Baptista, D.J. Miranda, S.B. Rosa, S.S. Rangel, R. Montezuma, R.A. Melo, E. Amaral

The evaluation of the occupational radiation doses using thermoluminescence dosimetry is based on the Harshaw 8814 dosemeter card and holder which contains LiF:Mg,Ti detectors. The system allows the measurement of the operational quantities Hp(10) and Hp(0.07), the personal dose equivalents at the depth of 10 and 0.07 mm, respectively.

In 2002, 6,922 workers from 720 facilities (aprox.) were controlled with this method on a monthly or a quarterly basis. The number of monitored workers distributed by fields of activity, namely, health, industry, research laboratories and mining are presented in Figures 5 and 6.

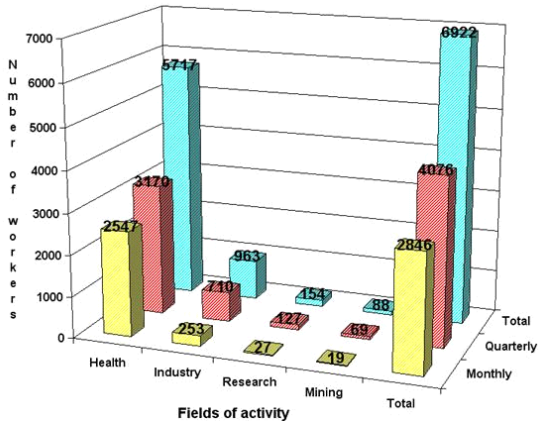


Fig. 5 – Number of monitored workers grouped by field of activity and monitoring period.

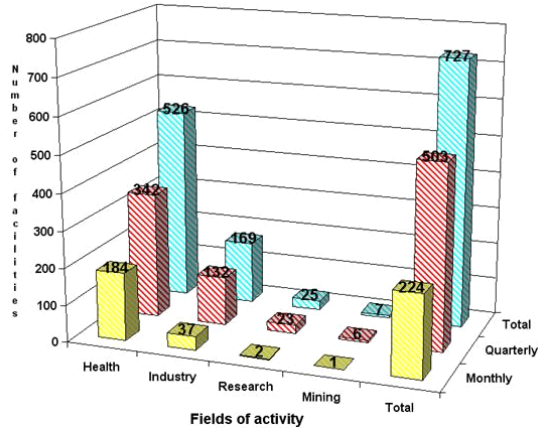


Fig. 6 – Number of facilities grouped by field of activity and monitoring period.

The distribution of the annual effective doses by dose intervals for the different fields of activity is presented in Figure. 7. It can be seen that the annual doses are distributed in two intervals E<0.5 mSv (~83%) and 0.5<=E<5 mSv (~15%). Annual doses exceeding 20 mSv were registered in less than 0,3% and the percentage of workers that received occupational doses higher than 10 mSv is approximately 1% of the total number of controlled workers.

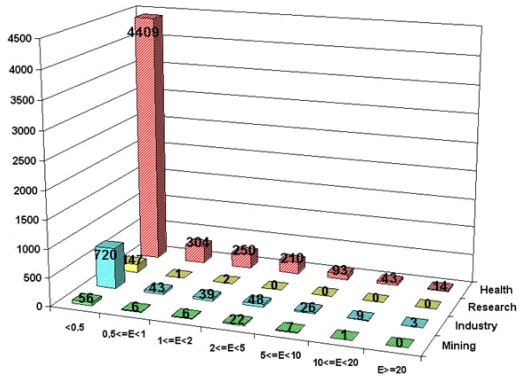


Fig. 7 – Distribution of the annual effective doses by dose intervals.

Using both Film and Thermoluminescence dosimetries, 54,860 assessed doses (approx.) were calculated. The total number of assessed doses and data for each monitoring period are displayed in Figure 8.

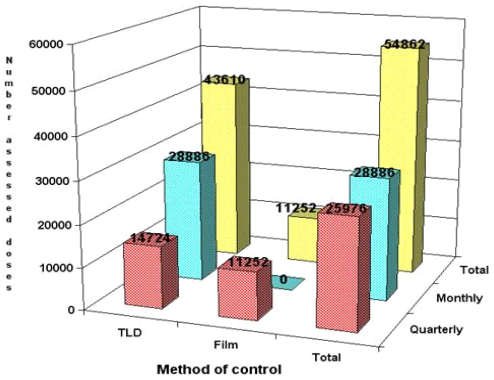


Fig. 8 – Total number of assessed doses in 2001.

III. Division of Metrology of Ionising Radiations

A.Ferro de Carvalho, L. Santos, J.Cardoso

Metrological control of instruments for measurement of ionising radiation is being carried out under a contract with Portuguese Institute of Quality and is the enforcement of Portaria 423/98 de 21 de Julho. Metrological control includes calibration and type testing. During 2002 were calibrated 45 dosimeters. About 500 TLD dosimeters were irradiated.

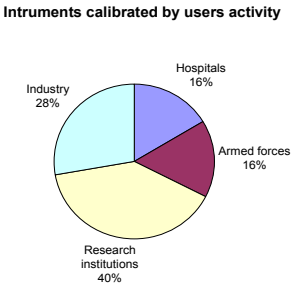


Figure 1: Instruments calibrated by user's activity

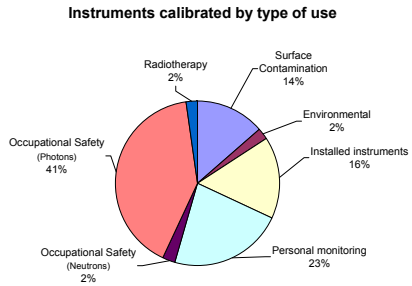


Figure 2: Instruments calibrated by monitoring type

IV. Division of Operational Radiological Protection and Radioactive Waste Management

1. Radioactive waste management

R.Trindade, I.Paiva, L.Portugal, F. Teixeira, R. Casquinha, M.Pacheco

Following the work developed on this matter in the previous year, radioactive wastes from the national producers were collected, treated and conditioned in cement matrix or iron drums for interim storage. During this year about 130 requests for radioactive waste collection were received.

2. Radioactive liquid discharges from hospitals in public sewage of Lisbon Borough Council (CML)

R.Trindade, I.Paiva, L.Portugal

A monitoring programme of radioactive liquid discharges from hospitals in the public sewage and Residual Water Treatment Plant (ETAR) of Lisbon was carried out in order to identify the radionuclides present and their activities. About 150 samples of liquid effluents were collected and analysed by quantitative and qualitative gamma spectrometry. This monitoring programme is contracted by CML.

3. Contract nº 6/01- A Study of Radioactive Liquids Discharges from the Medical Facilities – DGIES/ITN-DPRSN

R.Trindade, I.Paiva, L.Portugal

This Contract was signed between General Directorate of Facilities and Equipments for Health (Direcção Geral das Instalações e Equipamentos para a Saúde, DGIES) and Nuclear and Technological Institute/Radiological Protection and Nuclear Safety Department (ITN/DPRSN). The main objective is to identify the radioisotopes and amounts used in public hospitals, as well as the radioactive wastes

management strategies in place. The final output will advise the administration of public hospitals and Ministry of Health on radioactive waste management policies and will support the enforcement of regulations and good practices in medical facilities.

4. Radioactive liquid discharges from Oncology Portuguese Institute (IPO)

R.Trindade, I.Paiva, L.Portugal

A radiological survey of radioactive liquid waste from the Retention Tanks of IPO was carried out before being discharged in the public sewage. Samples of liquid effluents were analysed by quantitative and qualitative gamma spectrometry. This radiological survey is requested by IPO.

5. Radioactive liquids discharges from Nuclear and Technological Institute (ITN)

R.Trindade, I.Paiva, L.Portugal, A.Brogueira**,** R.Pombo, L.Brás

A radiological survey is carried out on radioactive liquid effluents from RPI, Chemistry Sector and Central Tanks before being discharged to Residual Water Treatment Plant. Samples of liquid effluents are analysed by quantitative and qualitative gamma spectrometry. The activities discharged are reported to the Radioactive Substances Committee of OSPARCOM.

6. Sealed sources licensing

R.Trindade, L.Portugal, I.Paiva, A. Rosa

According to Decree-Law nº 153/96 and Decree-Law nº 165/2002, requests related to import, export, utilization and transfer of sealed sources were analysed and licences of entrance in the national territory, transfer and possession were issued. In the current year about 191 licenses were issued. A national inquiry was carried out in order to identify the users, the existent sealed sources and their applications in Portugal.

7. Radioactivity in scrap metal

R.Trindade, L.Portugal, I.Paiva

Radioactive material was detected and collected during a radiological survey of trucks containing scrap metal at a smelting factory and at a scrap yard. Eleven cases of radioactive materials in scrap metal were detected this year.

8. Radioactive cargo in transit

R.Trindade, L.Portugal, I.Paiva, D.Alves

A radiological monitoring and the verification of international rules compliance were carried out when ships transporting radioactive cargo called Portuguese harbours. This year 5 ships calling Lisboa harbour were controlled.

9. Nuclear vessels

R. Trindade, L. Portugal, I.Paiva, A.Brogueira**,** C. Pires, J.Gouveia, P.Duarte, J.Oliveira A. Libânio, M.A. Tavares, H. Guerreiro V. Silvino, R. Casquinha, M.A. Pereira, C. Costa

An environmental radioactivity survey is carried out each time a nuclear vessel stayed at national harbours. The programme consisted on continuous monitoring of radioactive aerosols and airborne radioiodine. Samples of water, sediments and biological species were also collected for gamma spectrometry analysis. Sampling was done before, during and after the stay of the vessel. Results are reported to Ministry of Defence. Two nuclear vessel stayed near Lisbon harbour this year. In order to detect significative changes to the radiological background of Tagus River during the presence of nuclear vessels, a radiological survey was previously carried out to establish a baseline.

V. Medical Office

- Occupacional Medicine
- Curative Medicine
- Clinic Pathology Laboratory

J.E.R. Costa

The medical services develop four different kinds of activities:

- Occupational medicine, in particular concerning radiation protection, including medical inspections for workers exposed to ionizing radiation;
- Curative medicine, as a complementary service to ITN workers;
- Laboratorial medicine as support to the occupational medicine and curative medicine;
- Education in medical and biological aspects of radiation protection and medical advise in case of over-exposure.

During the current year (2002) the activities of the Health Service of DPRSN, serving all ITN, were seriously limited by shortage of staff due to retirement of the Nurse and the Technician. Both were in charge of the paramedical and admnistration activities of the Medical Office. Their urgent replacement was requested in due time through thr DPRSN Notes 12/2002 of 10th January and DPRSN-307/2002 of 11th September. With their retirement, the activities that suffered the most were the Clinical Analysis and the Occupational Medicine.
A total of 527 medical examinations have been performed during the year 2002.