Department of Radiological Protection and Nuclear Safety

Fernando P. Carvalho

The competences of the Department of Radiological Protection and Nuclear Safety (DPRSN) were established by the Decree-Law 311/98 of 14 September. These competences have been used as a guideline to the activities carried out by the Department, and this is reflected in the research projects implemented as well as in the services provided to the community.

During the year 2001 numerous actions were successfully accomplished by the Department. Amongst them we can list the safety assessment of 400 radiology facilities, the supply of individual dosimetry to more than 9000 workers, the intervention or evaluation in about 20 radiological accidents, the bio-medical analyses of radiation workers, the identification and recuperation of radioactive materials, such as lost sources in scrap metal, the inspection of ships transporting radioactive cargo, the radiological surveillance of the Lisbon harbour and of the Tagus estuary during the visit of nuclear ships. One shall add the control of the atmosphere, rivers, coastal seas, as well as foodstuffs and drinking water to ensure the radiological safety for the Portuguese population. Furthermore, in the last few months, marked by the threat of terrorist actions including the threat with nuclear/radioactive materials, the surveillance of radioactivity in public water supplies was also intensified.

Several externally funded research projects were also carried out, frequently in collaboration with other institutes, either national or international, leading to publications in scientific journals. During the same period one Doctoral Thesis was defended at the University and one internal thesis to acceed to Researcher, were passed by staff members. Furthermore, several projects were concluded and others were initiated. Proposals for new projects were also submitted to the Foundation for Science and Technology (FCT) and to the European Union, which are not described herein as there has been no response from the funding organizations yet. Notwithstanding these, the number of research contracts signed up during 2001 and new activities started indicate a multiplication of efforts made by the DPRSN, which is an indicator of the strong motivation of the staff.

Several activities deserve a special highlight. One is the preparation of the Quality Manuals and External Audits for the implementation of the Quality System (ISO 17025) for the Ionizing Radiation Metrology Laboratory, which is the outcome of a labourious effort of the staff. Another is the training abroad of young staff in radiation protection, rendered possible through an IAEA Technical Cooperation project, and the organization of two national training courses for professionals of industrial radiography and radiodiagnostic.

The more outstanding activity of the year was the sucessful accomplishement of the investigation on depleted uranium in the Balkans and on the contamination of the Portuguese military who served in UN peace-keeping missions in that region. The amount, quality and timing of the work performed by the DPRSN and its importance to the society, made it very relevant. This investigation, besides recognition by the international scientific community, was officially acknowledged by the Minister of Science and Technology (D.R., II Série, Nº. 148, Louvor nº. 472/2001 de 28 de Junho).

However, the year 2001 was also marked by serious flaws. The reduction in staff has continued with more retirements without replacement by young staff members, thus aggravating the already weak infrastructure of radiological protection of the country. The warnings sent out by the DPRSN and recommendations made by the ITN Advisory Committee in the year 2000´s report on staffing, activities and institucional policy in radiation protection, were ignored. Furthermore, the persistent lack of a national regulatory authority prevents the development of an effective radiological safety in the country.

At last, but not the least, the lack of an adequate building to receive the activities and equipment operated by the DPRSN, constrains the development of research and technical projects, and prevents the accreditation of analytical laboratories. This has also been recognized by the ITN Advisory Committee.

Keeping in mind these limitations, the achievements reported by the DPRSN in the following pages, certainly will deserve even more attention by the interested reader.

Staff

Director: Fernando P. Carvalho

Environmental Radioactivity

Researchers

- M. José Madruga, Principal Researcher (Group Leader)
- Alfredo Brogueira, Principal Researcher
- Fernando Carvalho, Principal Researcher
- M. Conceição Faísca, Principal Researcher[1]
- José Alberto Corisco, Researcher Assistant[2]
- Mário Reis, Research Assistant

Technical Personnel

- João M. Oliveira
- Graciete Ferrador
- M. Manuela Sequeira
- Helder Guerreiro, ITN grant
- Isabel Faria, ITN grant
- Jorge Gouveia, ITN grant,since 10/01
- Luis Ramos, ITN grant,since 11/01
- Rui Rodrigues, ITN grant
- Sandra Curado, ITN grant
- Victor Silvino, ITN grant

Auxiliary Personnel

- Albertina libânio
- Corália Costa
- M. Amélia Pereira
- M. dos Anjos Tavares

Students

- Anabela Lucas, MSc Student, ITN grant
- Carla Pires, MSc Student, ITN grant
- Irene Lopes, PhD Student, ITN grant
- Pedro Duarte, MSc Student, ITN grant
- Tânia Costa (BSc Student - Instituto Piaget, Almada)

Dosimetry and Biological Effects of Ionising Radiations

Researchers

- Augusto Oliveira, Auxiliary Researcher
- Estela Amaral, Auxiliary Researcher
- João Alves, Auxiliary Researcher
- José Pereira Luis, Principal Researcher
- Maria Berta Martins, Principal Researcher
- Maria Luisa Pedro, Auxiliary Researcher
- Octávia Gil, Auxiliary Researcher

Medical Doctor

- José Ribeiro e Costa

Technical Personnel

- Graciete Rangel
- José Sebastião Jesus
- Maria Adelaide Gameiro
- Maria Fernanda Fragoso
- Ana Rafael Roda (ITN grant)
- Maria João Figueiredo (ITN grant)
- Paula Silva (ITN grant)

Auxiliary Personnel

- Alice Oliveira
- Helena Santos
- João Paiva
- Maria Teresa Luzio

- Dulce Miranda, ITN grant
- Sandra Rangel, ITN grant
- Susana Rosa, ITN grant

Students

- Katia Jacob, MSc Student, ITN grant

Control of Radioactive Sources and Waste Management

Researchers

- Romão Trindade, Auxiliary Researcher (Group Leader)
- Maria Isabel Paiva, Auxiliary Researcher

Technical Personnel (Graduate)

- Luis Portugal

Auxiliary Personnel

- Firmino Teixeira
- Francisco Barreira Gomes (outposted at RPI)
- Ricardo Casquinha (ITN grant)

Metrology of Ionising Radiations

Researchers

- António Ferro de Carvalho, Principal Researcher (Group Leader)

Technical Personnel

- Luis Santos

Students

- João Victor Cardoso, MSc Student, ITN grant

[1] Retired during 2001
[2] Doing PhD

Administrative

- Ana Maria Rosa
- Dina Maria Alves
- Joaquina Monteiro
- Maria Emília Pacheco
- Maria Frederica Silveira

Driver

- Victor Cordeiro

Funding

	$\times 10^3$ PTE
Research Projects:	49 612
ITN:	37573
Services:	106 655
Total:	**193840**

Publications

Journals:	7 and 2 in press
Proceedings:	13 and 4 in press
Conf. Communications:	23
InternalReports:	35

HIGHLIGHT

Investigation on the Contamination of the Balkans and Portuguese Troops by Depleted Uranium from Weapons

F.P. Carvalho
and all DPRSN staff

Objectives

In the late 2000 and early 2001, the public concern with the exposure of UN peace-keeping forces in the Balkan region increased dramatically. There has been about 5000 Portuguese military staff participating in those UN missions. Several casualties that occurred among them, were ascribed to contamination with depleted uranium (DU) from ammunitions used in the region. A scientific mission of the ITN-DPRSN to the Balkans was approved by the Government to investigate this issue.

Results

A field mission was carried out to perform radiation measurements and to collect environmental and food

Figure 1- Monitoring radiation in a destroyed tank. Prlina (Kosovo)

samples for analysis. Uranium analyses were performed in urine samples from about 50% of the military staff. Analyses of lymphocytes for chromosome damage caused by radiation, were carried out in dozens of selected individuals. Radioactivity analyses were performed in tissues collected post-mortem from decesead individuals who had served in the Balkans. Altogether, results have shown that Portuguese staff was not contaminated with DU and that the environmental contamination in the Balkans was restricted to the sites impacted by the DU ammunition.

Similar studies carried out almost simultaneously by other countries and by international organizations, such as UNEP, have reported similar conclusions.

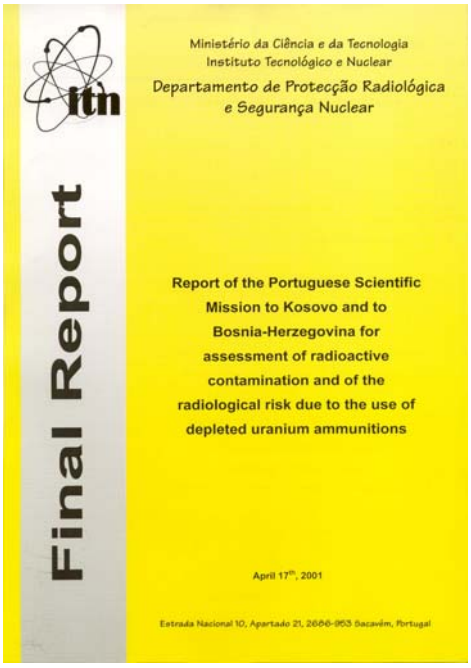


Figure 2- Final report

Published, accepted or in press work

1. Missão Científica no Kosovo e na Bósnia-Herzegovina para Avaliação da Contaminação Radioactiva e do Risco Radiológico Resultantes do Uso de Munições com Urânio Empobrecido. Preliminar Report, DPRSN, February 2001.
2. Report of the Portuguese Scientific Mission to Kosovo and to Bosnia-Herzegovina for Assessment of Radioactive Contamination and of the Radiological Risk Due to the Use of Depleted Uranium Ammunitions, Report DPRSN-A, nº. 14, ISBN 972-8660-17-0.
3. Listagem dos Resultados das Concentrações de Urânio na Urina Determinadas por Medida Beta Total e Espectrometria Alfa. Report DPRSN-C, Nº 29, October 2001.

Environmental Radioactivity

Environmental Radioactivity

Maria José Madruga

Environmental radioactivity has always been one of the areas of more intense research and technical activity of the DPRSN. This 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 area, research activities have accompanied and complemented monitoring activities. Actually, environmental survey, radioecology experiments and modelling are activities converging towards the same global objective: radiological environmental impact assessment.

Current monitoring activities mainly concern rivers whose basins receive effluents from Spanish nuclear power plants (Tejo), terrestrial environmental radioactivity due to atmospheric fallout or enhanced natural radioactivity, and atmospheric radioactivity due to cosmic radiation. Current research projects are related with these programmes 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 the group 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 (Decree-Law nº243/2001) and mineral waters, radioactivity analysis of foodstuffs and goods to export, and radon measurements in indoor atmosphere.

In the first six months of this year the environmental radioactivity staff has been hardly involved on the assessment of radioactive contamination and of the radiological risk due to the use of depleted uranium ammunitions in the Balkans. Radioactivity analysis was performed in soil, foodstuff, water and aerosol samples collected in the region. About 150 samples were analysed by gamma spectrometry (natural and artificial radionuclides) and 90 by alpha spectrometry (uranium isotopes).
The team was also asked to collaborate in a medical survey of all the military personnel who served in the Balkans through the analysis of uranium in urine samples. Urine samples of about 3000 individuals were analysed using the global beta measurements and 60 by alpha spectrometry (uranium isotopes). To comparison, urine samples of individuals (military and civilians) who had not been in Balkans were also analysed. Two hundred samples were analysed by global beta measurements and fifty by alpha spectrometry.
Uranium analysis in tissue samples collected post-mortem of an individual who served in the Balkans was performed. Uranium analysis using alpha spectrometry in six tissue samples of this individual and twelve reference samples was carried out.

The group has also collaborated in the elaboration of a Project submitted to FCT for the assessment of environmental contamination around abandoned uranium mines.

Aquífers and Surface-Waters in the Chernobyl Area- Observations and Predictive Evaluation

M.J. Madruga, T. Costa[1], I. Faria, C. Costa, J. Smith[2], A. Konoplev[3], R. Comans[4], A. Kudelsky[5], G. Laptev[6] and G. Zibold[7]

Objectives

To characterize sediment samples from Belarussian, Russian, Ukrainian, German lakes (Chernobyl contaminated areas) and Tejo river (Portugal) in terms of Frayed Edge Sites (FES) capacity and Radiocaesium Interception Potential (RIP) in the presence of ammonium or potassium ions. To perform ^{137}Cs sorption kinetics for sediment from lake Constance.

Results

Langmuir linearisation of caesium sorption isotherm allows to determine FES and High Affinity Sites (HAS) of high organic bottom sediments for which well-defined plateaus were not reached as a result of lattice interlayers collapse. Introduction of ammonium acetate extraction of exchangeable caesium, after equilibrium, improves the accuracy of the RIP measurements and allows avoiding the influence of caesium fixation on the results of measurements. Radiocaesium fixation plays a significant role in case of RIP determinations. Values three and two times higher in case of RIP_K and RIP_{NH4} respectively, were found [1, 2]. The results of the ^{137}Cs dynamic in water phase of different PAR (potassium adsorption ratios) show that about 100% of caesium is adsorbed in the first 24 hours. The generation of ammonium during the experiment originated the extraction of a quantity of radiocaesium from the sediment (Fig.1). This is corroborated by the evolution of ammonium concentration in liquid phase with time. No effects of the water phase composition (PAR values) on the radiocaesium fixation were verified.

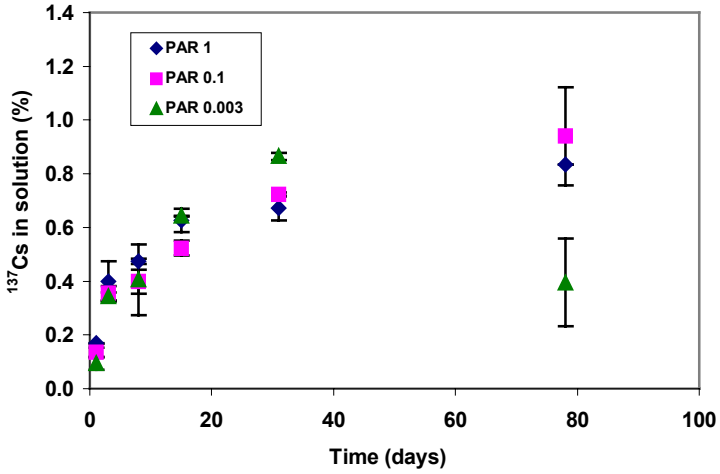


Fig 1- Kinetics of radiocaesium fixation for Constance lake sediment at different potassium adsorption ratios (PAR)

Published, accepted or in press work

1. T. Costa. Caracterização de sedimentos de água doce, provenientes de regiões contaminadas após o acidente de Chernobyl: adsorção específica para o radiocésio. Graduate Thesis, ISEIT, Almada, July 2001.

2. M.J. Madruga, A. Konoplev, I. Konopleva. Methodology improvement of radiocaesium sorption determination on bottom sediments from Chernobyl contaminated areas. *Colloquium Series of the Radioprotection Journal* (In press).

[1] graduate student, Instituto Piaget, Almada, Portugal
[2] Centre for Ecology and Hidrology, United Kingdom
[3] SPA "Typhoon", Russia
[4] Netherlands Energy Research Foundation, The Netherlands
[5] Institute of Geological Sciences, Belarus
[6] Ukrainian Hydrometeorological Institute, Ukraine
[7] Fachhochschule-Weingarten, Germany

Environmental Impact of the Urgeiriça Uranium Mill Tailings

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

Objectives

To evaluate the environmental impact of natural radionuclides, mainly ^{226}Ra and ^{210}Pb, and heavy metals at Urgeiriça uranium mill tailings (Fig. 1) in what concerns its dispersion in the environment and transfer to plants (pines, eucalyptus and shrubs) growing in the tailings.

Results

The ^{210}Pb activity in solid wastes, soils and plants (aerial part and roots) collected at the Urgeiriça mill tailings and surrounding area has been determined by gamma spectrometry. Results obtained indicate that ^{210}Pb uptake by plants from the tailings is a non-linear function, tending to a linear relationship at higher ^{210}Pb concentrations in the tailings. The ^{210}Pb concentration ratios decrease at low ^{210}Pb concentration in the tailings and appears relatively constant at higher lead concentrations.

Exchangeable and total cations (K^+, Ca^{2+} and Mg^{2+}) have been determined in solid wastes (after ammonium acetate extraction) and plants (after sample digestion) by ionic chromatography [1]. The cationic concentration in plants and solid wastes will be correlated with the ^{226}Ra solid wastes/plants transfer factors.

Geochemical characterization and contamination levels on the major heavy metals and trace elements associated with this mineralization area were carried out by the Group of Environmental Analytical Chemistry (responsible M.F. Araújo) of the Chemistry Department. The results obtained are described in the activities report of this group.

Fig 1. Urgeiriça uranium mill tailings

Published, accepted or in press work

1. M.J. Madruga, I. Faria. A cromatografia iónica na análise de catiões em plantas. Actas do 2º Encontro Nacional de Cromatografia, Lisboa, 10-12 Dezembro 2001.

2. M.F. Araújo, T. Barbosa, M.J. Madruga, I. Faria. Dispersão de contaminantes e sua transferência no sistema solo/planta nas escombreiras da mina de urânio da Urgeiriça. Actas do Congresso Internacional sobre Património Geológico e Mineiro, Beja, 4-7 Outubro 2001.

3. M.J. Madruga, A. Brogueira, G. Alberto, F. Cardoso. ^{226}Ra bioavailability to plants at Urgeiriça uranium mill tailings. *J. of Environmental Radioactivity*, 54, (2001) 175-188.

4. M.J. Madruga, I. Faria, A. Brogueira. Spatial distribution of ^{238}U, ^{226}Ra and ^{210}Pb at Urgeiriça uranium mill tailings. *Radioprotecção*, Vol I, nº8-9, (2001) 125-134.

Contamination of Tropical Coastal Lagoons

F.P. Carvalho, J.M. Oliveira and J.P. Villeneuve[1]

Objectives

To investigate the current levels of atmospheric contaminants such as pesticides, herbicides, PCBs and radionuclides, in intensively used water bodies in coastal areas.

Results

Analyses of contaminants were performed in sediment, water and biota samples collected in lagoon systems in Mexico (Laguna de Terminus) and Brazil (Parguaçu estuary and All-Saints Bay). Toxicity tests were carried out "in situ" by other laboratories associated to this project, to assess the effect of contaminants in aquatic test organisms.

In the lagoon systems investigated, the main contaminants accumulated in bottom sediments were always the persistent organochlorine compounds. PCBs, which are organic contaminants from industrial origin, are also generally present but in lower concentrations than DDTs. Herbicides were not detected in the water and sediment samples analysed.

Amongst the radionuclides analyzed, ^{137}Cs was present in trace concentrations only. The radionuclides from natural series are the more widespread, especially uranium isotopes, ^{226}Ra, ^{210}Pb and ^{210}Po.

The data on naturally-occurring radionuclides in aquatic biota, such as mussels, oyster and fish, are being used to assess the radionuclide intake by the local population. The desiquilibrium ^{226}Ra-^{210}Pb in cores of the bottom sediments from the lagoon is applied to date the accumulation of organic contaminants in the sediments.

Results from related studies on similar coastal environments were published.

This project is an international collaborative study, funded by the European Union (DGXII).

Figure 1- Study area: All-Saints Bay, Brazil

Published, accepted or in press work

1. F.P. Carvalho and F.S. Civili. Monitoring of the Mediterranean Sea Pollution (MED POL) and Data Quality Assurance, *Intern. J. Environ. Studies, 2001, Vol. 58*, 139-158.

2. Dang Duc Nhan. F.P. Carvalho, Nguyen Manh Am, Nguyen Quoc Tuan, Nguyen Thi Hai Yen, J.-P. Villeneuve, C. Cattini, Chlorinated pesticides and PCBs in sediments and molluscs from freshwater canals in the Hanoi region. *Environment Pollution 112 (2001)* 311-320. .

[1] International Atomic Energy Agency, Marine Environment Laboratory, BP 800-MC98012, Monaco.

Transport of ^{137}Cs and ^{90}Sr by Microalgae *Chlamydomonas reinhardtii*

José A.G.Corisco[1] and José Fernandez[2]

Objectives

The aim of this thesis is to elaborate a model of the transport mechanisms for the cations $^{137}Cs^{+}$ and $^{90}Sr^{2+}$ in the unicellular green algae *Chlamydomonas reinhardtii* Dangeard.

For that, the proposed objectives are to study the effects of selected variables in the uptake rates and internal accumulation of the radioisotopes, and the kinetic properties of both stable elements. The variables

Under observation are external K^{+}, Ca^{2+}, Na^{+} and pH. Also a study of the effect of channel blockers and metabolic inhibitors is being done. Studies are made with algae adapted to both sufficiency and deficiency of K^{+} in a simplified freshwater medium, with pH controlled by biological buffers.

Results

Results were obtained for the study of variables K^{+}, Ca^{2+} Na^{+}, pH and kinetic properties of Cs^{+}. Kinetic properties of Sr^{2+}, effect of channel blockers and inhibitors is being concluded. Analysis of data is being thorouly performed. Some preliminary results are presented (Fig 1).

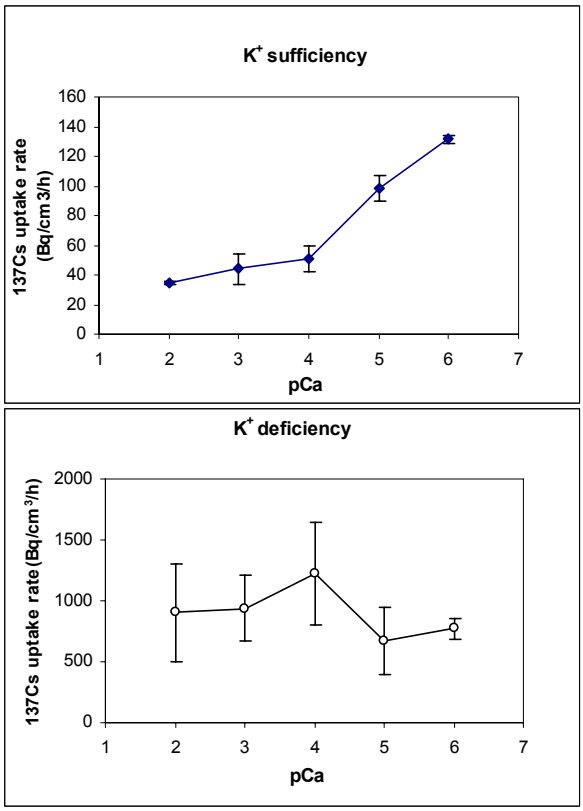


Figure 1. Changes in the ^{137}Cs uptake rate in algae adapted to K^{+} sufficiency (5mM) and deficiency (1µM) , as a function of external Ca^{2+} activity (pCa 2=10^{-2}M Ca^{2+}... pCa6= 10^{-6}M Ca^{2+})

Published, accepted or in press work

1. A. Linares, R. Zapico, J.A. Corisco, J.A. Fernandez, Transporte de Radiocésio (^{137}Cs) en *Chlamydomonas reinhardtii*. Efecto del pH sobre la incorporación y acumulación. *VII Congreso Hispano Luso de Fisiologia Vegetal*, Badajoz, España, 2001.

[1] DPRSN (ITN)/University of Málaga (Spain)
[2] University of Málaga

Study of Aerosol Deposition Processes Using Natural Radionuclides as Tracers

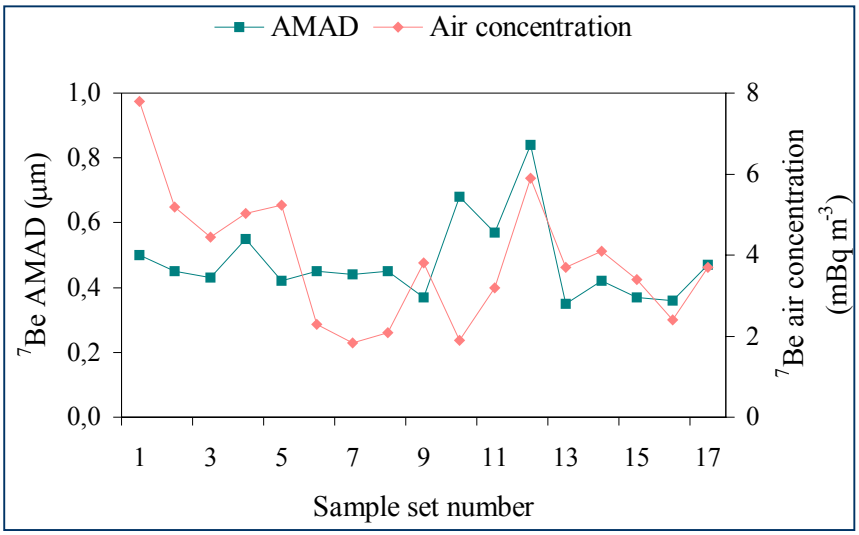
M.J. Reis, R.N. Rosa[1], A.O. Bettencourt[2] and A.L. Brogueira

Objectives

The main purpose of this project is the study of atmospheric aerosol deposition processes and air masses origin by using natural radionuclides as tracers.

Results

Natural radionuclides are continuously produced in the atmosphere and participate in the formation and growth of the accumulation mode aerosol. The activity ratios of ^{7}Be (cosmogenic) and ^{210}Pb (terrestrial) were used to estimate the stratospheric influence on the composition of tropospheric air and the evolution of the activity median aerodynamic diameter of ^{7}Be was used to derive tropospheric aerosol residence times. The short-lived ^{212}Pb and ^{214}Pb were used to trace dry deposition of submicron aerosol particles onto surfaces. The derived ^{212}Pb deposition fluxes are consistent with the results reported in the literature. The higher deposition values obtained for ^{214}Pb aerosols could be a result of the contribution of unattached ^{218}Po. Total aerosol particles were collected by using high-volume samplers and fractionated aerosol samples were carried out by using an inertial cascade impactor. All the samples activity was measured by γ-ray spectrometry using both coaxial and low-background well-type HPGe detectors.



Published, accepted or in press work

1. M.J. Reis. A.L. Brogueira, R.N. Rosa, A.O. Bettencourt, Measurement of ^{214}Pb, ^{212}Pb, ^{210}Pb and ^{7}Be Activities in Size Fractioneted Aerosols in the Lower Atmosphere at Sacavém (Lisbon), *Proceedings of the V IRPA Regional Congress on Radiation Protection and Safety*, Recife, Brasil (2001).

3. M.J. Reis, R.N. Rosa, A.L. Brogueira, A.O. Bettencourt, Natural Radionuclides as Atmospheric Tracers, *International Meeting on Climate Change and the Kyoto Protocol*, Évora, Portugal (2001)

4. M.J. Reis, R.N. Rosa, A.L. Brogueira, A.O. Bettencourt, The Use of Natural Radionuclides to Trace Dry Deposition of Submicron Aerosols, *VIII Jornadas Portuguesas de Protecção Contra Radiações*, Lisboa, Portugal (2001).

[1] Departament of Physics, Évora University
[2] PhD Thesis Supervisor (retired)

Environmental Impact Assessment of Uranium Mining and Milling in Old Mining Sites

F.P. Carvalho, M.J. Madruga and J.G. Alves

Objectives

To assess the environmental contamination in most of the 54 uranium old mining sites and milling sites in the country. Results will monitor and advise the environmental rehabilition program to be undertaken in abandonned/old mining sites. This project aims at assessing the risk for the public health posed by contamination with radioactive materials.

Results

This project started in mid 2001. A preliminary field survey was carried out in May, with the participation of an IAEA expert, to identify old mining sites, to assist with the design of the field sampling programme, and to exchange information with the mining company (ENU).

A contribution was provided to a workshop on the environmental rehabilitation of uranium mining sites, organized in Urgeiriça, July 2001. A summary of the previous work carried out by the DPRSN in uranium regions was presented.

Collaborative work between the ITN-DPRSN and IGM-Laboratory was planned in order to assess contamination both by radioactive and non-radioactive metals in the uranium mining areas.

The preliminary assessment of the impact of past uranium mining activities on public health was carried out, through the statistical evaluation of the mortality data by one partner laboratory (INSA). This assessment provisionally concluded that a higher incidence of lung cancer exists in the uranium milling county in comparison with other counties of the north of Portugal.

Full implementation of this project is planned for 2002-3. This research (ITN-DPRSN) is partly supported under the IAEA contract POR/4/015.

Fig. 1- U-exploitation region in Portugal (dots represent former mining sites)

Published, accepted or in press work

1. F.P. Carvalho, M.J. Madruga, J. Alves. Contaminação radioactiva nas áreas mineiras uraniferas", Relatório DPRSN B, N.º 15 (2001). ISBN: 972-95401-5-2

Transuranium Levels in the Marine Environment

A. Lucas, J.M. Oliveira, A. Libânio and F.P. Carvalho

Objectives

To determine the current levels of plutonium and americium in the marine environment along the Portuguese coast. These data will be compared with preliminary results obtained one decade ago in order to assess trends of contamination by these long-lived radionuclides.

Results

Transuranium nuclides, especially plutonium and americium isotopes, entered the North Atlantic mainly through the dumping of radioactive waste in the deep ocean, the releases of liquid wastes from reprocessing of spent fuel in Sellafield (UK) and La Hague (France), and atmospheric fallout of radioactive debris from nuclear tests. New sequential radiochemical techniques for separation of Pu and Am, followed by analysis by low background alpha spectrometry were tested using sample materials of various matrix and IAEA Certified Reference Materials. Samples of mussels, sediments and seaweeds were collected in various locations along the coast. Large volume water samples were collected also for transuranium determination. Analyses are underway.

In order to assess the current levels of transuranium deposition from the atmosphere, large volume air filters and surface layers of soils were also analysed. Preliminary results of the year 2001, indicate that current levels of $^{239+240}$Pu in the surface air at Sacavém are about 3.1 nBq m^{-3}. Results of analyses of surface soils indicate $^{239+240}$Pu concentrations up to 0.43 Bq kg^{-1} and ^{238}Pu concentrations up to 0.02 Bq kg^{-1}. Results of our analysis of IAEA Reference Materials are in agreement within 3% and within 10% for $^{239+240}$Pu and ^{238}Pu respectively, with the certified values.

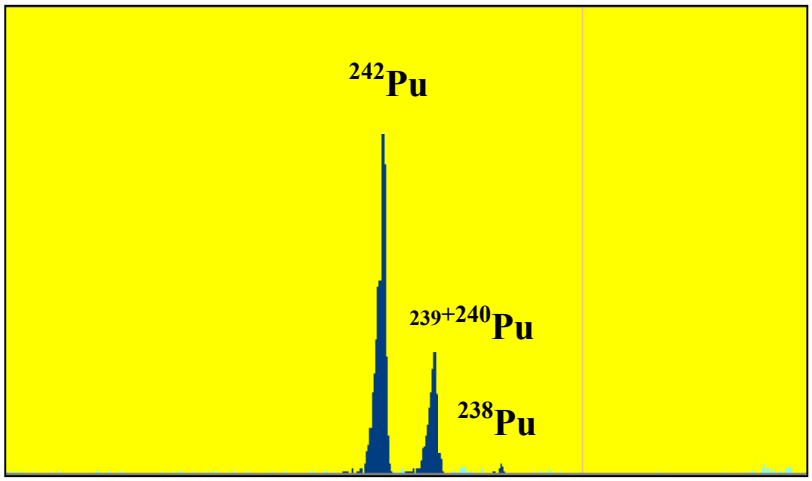


Figure 1- Plutonium isotopes in a sample of marine sediment.

Efficiency Determination for Gamma Spectrometry Systems by Numeric Methods. Application to a Case Concerning Environmental Radioactivity

C. M. S. Pires and A. L. M. Brogueira

Objectives

The availability of modern large volume, low background detectors in environmental applications, implies the introduction of an algorithm for the evaluation of the radioactivity in bulk samples, and of corrective parameters related to the geometry (sample dimensions, solid angle and self-absorption coefficients for different materials). The objective of this project is the application and development of the correlation parameters to enhance the sensitivity leading to lower MDAs and better uncertainty values in evaluated activities. Determination of ^{40}K and ^{137}Cs activities in the food chain products using the referred method will be carried out.

Results

A point source has been used to determine the absorption coefficients of different materials and then correct the efficiency values for them. The experimental setup was done with a virtually point source at a fixed distance (5 cm) to the detector, the volume between each other being filled with different materials. Preliminary results for water as absorber are presented in figure 1. It can be seen that absorption effects are net, namely to the lowest energies. A reduction in efficiency when the air layer changes to water, for 122 keV, is about 46,2%.

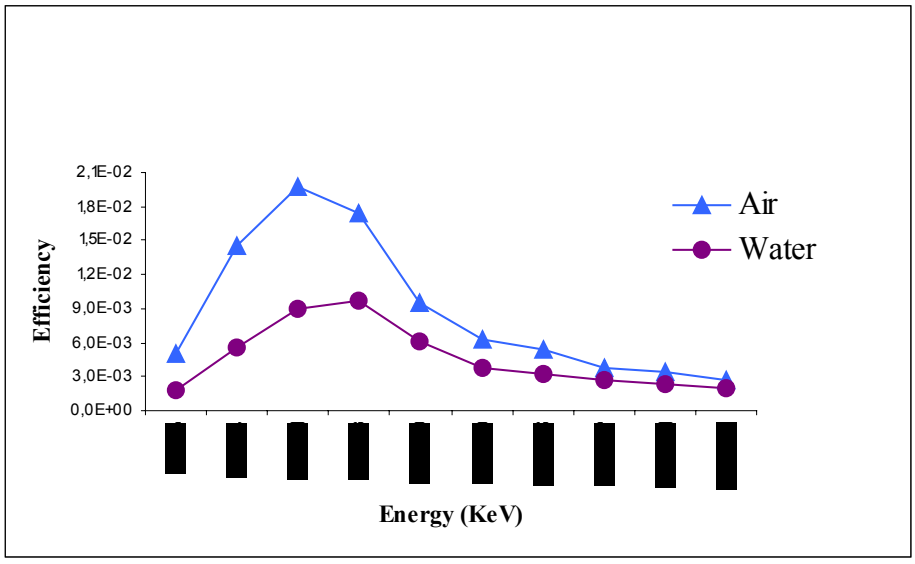


Fig. 1 Efficiency curves for air and water.

Radon Concentrations in Dwellings and Radioactivity of Construction Materials

M.C. Faísca, P.M. Duarte, F.P. Carvalho, C.M. Pires,A. Brogueira

Objectives

Radon, through inhalation, is the main contributor to the radiation dose received by humans. In houses radon concentrations tend to build up, enhancing the exposure to radiation.

Breakthrough studies on this issue have been carried out by the DPRSN in the past. Current EU recommendations on indoor radon concentration limits, as well as increased public awareness of exposure to radon offered the opportunity to revisit this subject and to implement a new phase of research on radon in dwellings. The survey discriminate geologic, building material, floor and ventilation parameters. This study also allowed the identification of radon-prone areas. Construction materials may be a significant source of radon to indoor air. The analysis of radionuclides in marketable rock used in construction was carried out.

Results

The alpha-track detectors (LR-115) used for radon measurements were distributed in 72 municipalities, with special incidence in granitic regions, during Spring 2001.

The radon concentrations ranged between 6 and 1750 Bq m^{-3}, with half of the sample showing values under 150 Bq m^{-3}, while 14 measurements (5%) exceed 800 Bq m^{-3}.

The results analysed concerning the different floors of dwellings, showed higher concentrations at ground floor (median = 200 Bq m^{-3}) decreasing with the distance to the soil surface.

The influence of the geology on the indoor concentrations of radon was demonstrated with the results obtained in two separate groups of houses: in granitic regions = 289 Bq m^{-3}; remaining regions = 117 Bq m^{-3}. Other supplementary statistical parameters and tests further underscore this conclusion.

Measurements performed in selected dwellings have shown the influence of the building materials on the indoor radon concentrations. Houses with walls built in granite displayed an increase in radon concentrations in comparison with houses built with other materials.

The results are summarized below, in a map with georeferenced samples (dwellings) and granitic regions, corresponding to 25% of continental Portugal area (Figure 1).

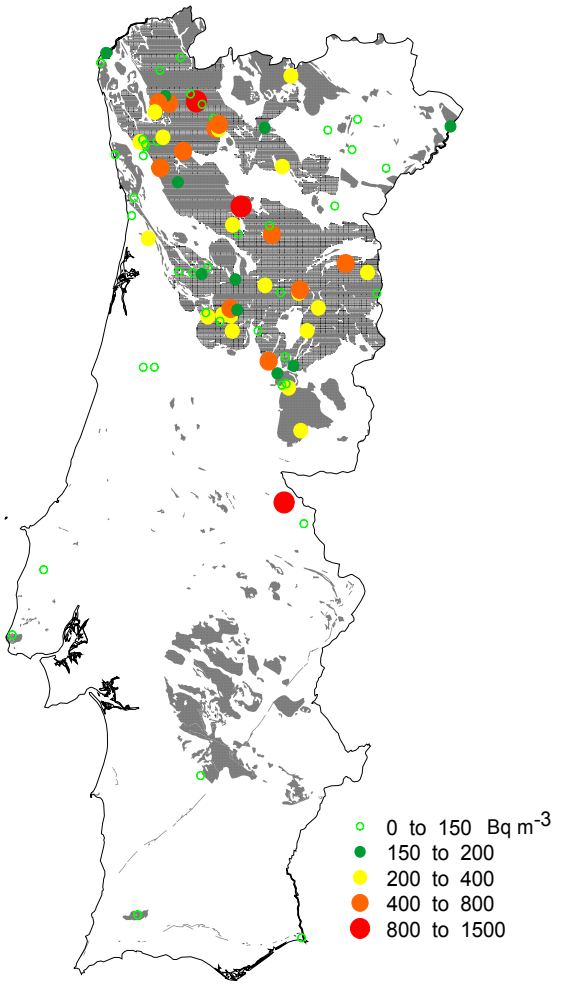


Figure 1 - Location of studied dwellings and concentration levels of indoor radon.

Published, accepted or in press work

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2. C. M. Pires, A. Brogueira, P. M. Duarte, F. P. Carvalho. Determinação de Radionuclidos Naturais em Rochas por Espectrometria Gama. Apresentação oral na Conferência Ibérica sobre Protecção Ambiental. Instituto Piaget – Viseu, Julho 2001.

Radioactivity in Bottled Mineral Waters

F.P. Carvalho, J.M. Oliveira, M.M. Sequeira

Objectives

The consumption of natural mineral waters by the Portuguese population has known a steady increase in recent years. However, beyond the concentrations of major ions the composition of these mineral resources is poorly known. A research programme, jointly carried out by the Geological Survey (IGM), the ITN-DPRSN and the Chemistry Association AEMITEQ, was started to investigate the chemical composition and finger-prints of all spring waters and bottled mineral waters of the country. During this year, 26 out of the 32 bottled mineral waters were analysed.

Results

The analyses were carried out using samples from the archives of the industrial water companies. The analysis of radioisotopes included the main alpha emitters from the uranium and thorium series and the beta emitters ^{210}Pb and ^{3}H. Radon was not analysed.

In general, radioactivity in these waters (U, Th, Ra) increases with the total salt content. There are, however, exceptions and some low salt content waters display relatively high concentrations of dissolved ^{210}Po from the decay of radon.

Interestingly, the ^{234}U/^{238}U isotopic ratio in waters shows that in some of them the ratio in close to unity whereas in others it is much higher than unity. This feature relates to the age of the underground water and with the geologic environment of the aquifer.

Tritium in the water was generally low, < 3.5 Bq/L, much lower in comparison to legal limits for ^{3}H in water from public supplies (50 Bq/L).

The results of the first phase of this project were delivered to the Industrial Association of the producers of bottled mineral waters, last December 7. A second phase of this project (2002-3) will allow the analyses of all spring waters in the country.

This project was partially funded through a contract with the Industrial Association of this economy sector.

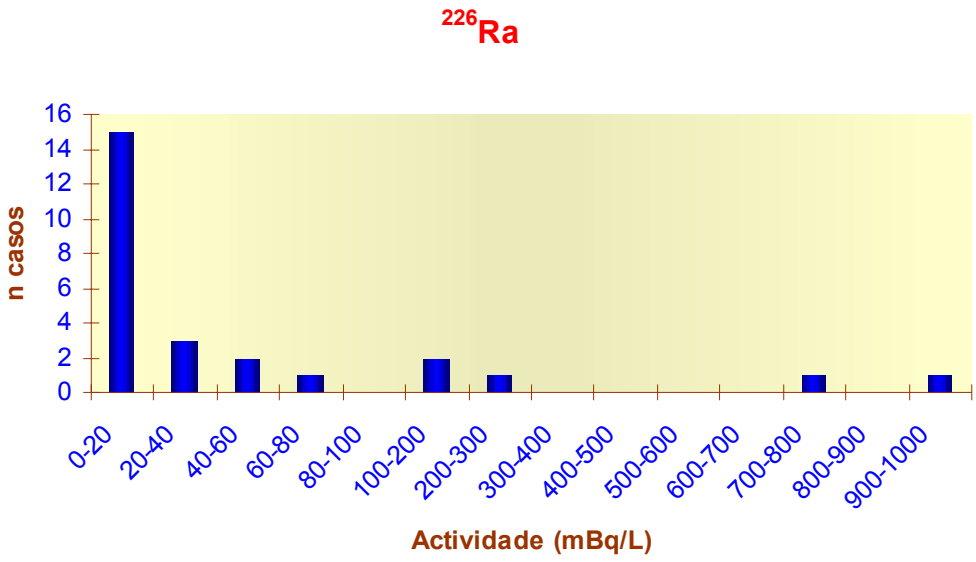

Figure 1- Concentration of ^{226}Ra in bottled mineral waters

Published, accepted or in press work

1. M. Leite, F.P. Carvalho, P. Nogueira, "Bottled mineral waters - a characterization study". IGM, ITN-DPRSN, AEMITEQ Report for the APIAM. Dec. 2001.

Radioactivity in Tejo and Zêzere Rivers

A. Brogueira, M.M. Sequeira, M. A. Pereira, V. Silvino, C. Pires and R. Rodrigues

Objectives

To perform a survey of natural and artificial radioactivity in Tejo river, where exist nuclear installations (upstream in Spain) and in Zêzere river, which does not suffer the influence of the nuclear installations and is serving as a background to Tejo river.

Results

Monthly sampling of water, sediments, hydrophytes and fish are carried out at three stations in Tejo river (Vila Velha de Ródão, Fratel dam and Valada do Ribatejo). Monthly sampling of water is also carried out at Castelo de Bode in Zêzere river. At Fratel and Sacavém rain water is also sampled. The ^{137}Cs is usually detected in all compartments of the river ecosystems; ^{90}Sr and ^{3}H are only measured in river and rain water.

Natural radioactivity (^{226}Ra, ^{228}Ra, ^{235}U) is measured in sediments, hydrophytes and fish.

Radiochemical analyses of river water are carried out in 40 liter of 0.45μm filtered samples. Methods for ^{137}Cs, ^{90}Sr and ^{3}H radiochemical analyses are described in previous papers. River bank sediments, after drying, are subjected to quantitative gamma spectrometry on the whole and on two sediment fractions. Fish and hydrophytes from the most common species at the sampling stations are dried, ashed and analysed by gamma spectrometry. Beta activity measurements are performed in a low-background gas flow counter. Tritium is measured by liquid scintillation.

In the framework of the Regional Programme of Research and Technological Development of Extremadura Commission (Spain) a collaborative programme between the ITN/DPRSN and the Departmento de Física da Faculdade de Veterinária (Universidade de Extremadura) was carried out that focus on research of radionuclides (^{90}Sr and ^{137}Cs) transport mechanisms in sediments and water, concerning Arrocampo (cooling pond of Almaraz NPP) and the dams of Arrocampo, Torrejon, Alcantara and Cedillo in Spanish part of Tejo river and Vila Velha de Ródão, Fratel dam and Valada do Ribatejo in the Portuguese part (1,2). Intercomparison of methods and results was performed.

One join paper was presented at the 27ª Reunión Annual de la Sociedad Nuclear Espanola, León, 3-5 October 2001.

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2. A. Baeza, A. Brogueira, C. Miró, M.M. Sequeira, Study of Caesium-137 in Surface Waters and sediments of the Tagus River, *International Congress on the Radioecology-Ecotoxicology of Continental and Estuarine Environments,* Aix-en-Provence, France, 3-7 September, 2001, poster.

Environmental Survey Network

M.C. Faísca, M.M. Sequeira, G. Ferrador, M. Reis, C. Pires, R. Rodrigues, S. Curado, M.A. Tavares

Objectives

The DPRSN carried out a National Monitoring Programme for the determination of radioactivity in superficial and human consumption waters, milk and mixed diet. This programme has been planned in accordance with the European network for environmental radioactivity, following the requirements of Artº 35º and Artº 36º of the EURATOM Treaty.

Results

Samples are regularly collected from different regions of the country, accordingly with international sampling procedures and analysed for the determination of artificial radionuclides, using gamma spectrometry and beta measurements.
All data are therefore formatted accordingly with the *Easy Proteo Input Processor* and sent to the EU Joint Research Centre, ISPRA, where they are introduced into the European Database.

Published, accepted or in press work

1. Environmental Radioactivity in the European Community 1994. *Radiation Protection nº 103*, EUR 18663 EN, 79. ISBN 92-828-5389-6 (2001)
2. Atlas of Caesium Deposition on Europe after the Chernobyl Accident. EUR 19801 ENRU. ISBN 92-894-1004-3 (2001)

Radioactivity in Hospital Waste Discharges

F.P. Carvalho, M.M. Sequeira, A Brogueira, C. Pires and A. J. Pereira

Objectives

To identify the radioisotopes and amounts used in public hospitals, as well as the conditions of handling, storage, and application of radioisotopes and the disposal of radioactive waste. This project aims at assessing the radiological safety of hospital practices, and at assessing the environmental contamination caused by discharges of radioactive wastes. The final output will advise the administration of public hospitals and the Ministry of Health on waste management and will support the enforcement of regulations and of good practices in medical facilities.

Results

From on-going studies on radioactive waste discharges performed in Lisbon, it is known that the sewage system of the city receives radioactive discharges from Hospitals and medical laboratories. In the sewage, ^{99m}Tc, ^{131}I and other radionuclides have been measured. On occasion, these nuclides were above the concentrations set as legal limits for radioactivity in liquid discharges. Although undergoing dilution in the urban sewage system, these radionuclides were still detected at the municipal waste water treatment plant of Alcantara and, occasionally, ^{131}I has been measured in biota samples collected from the Tagus esturay.

A preliminary survey of the radioisotopes currently used in public hospitals country wide, confirmed that ^{131}I, ^{99m}Tc, ^{3}H are amongst the more widely used radioisotopes in diagnostic (both “in vivo” and “in vitro”), therapy and research. However, hospitals also handle other radiosiotopes such as ^{32}P, ^{35}S, ^{125}I, ^{14}C. A total of 12 hospitals was selected for a more detailed assessment of practices in waste discharge to be performed in 2002. This will expand the studies to hospitals outside Lisbon, where no radiological risk assessments for open sources were carried out as yet.

The radiological risk assessment of radioactive waste discharges, and the radiological safety assessement of practices in radioisotope laboratories of Hospitals, is providing useful advise to Hospitals Administration. The output of this project will assist Health autorithies to improve the handling of Hospital radioactive waste.

This project is partly funded under a contract with the Municipal Administration of Lisbon (CML) and a contract with the Ministry of Health, Hospital Administration.

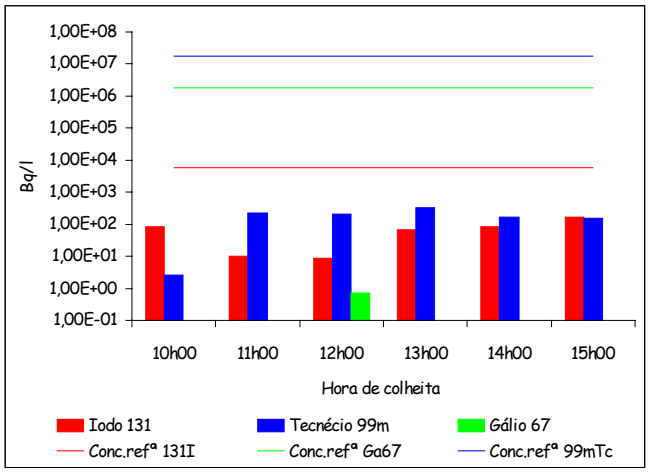

Figure 1- Radioactivity in sewage at the waste water treatment plant of Alcantara (colab.with CML)

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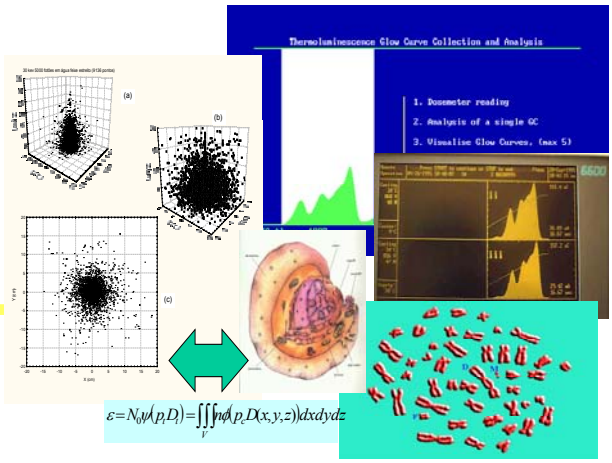
1. F.P. Carvalho, “Cuidados a Ter na Utilização de Substâncias Radioactivas nos Hospitais”, Relatório DPRSN B Nº.13, 2001. ISBN:972-95401-6-0.

2. M.M. Sequeira, C. Pires, A. Brogueira, Medidas de Radioactividade Artificial em Águas Residuais da Rede de Saneamento de Lisboa, durante o Ano 2000. Report DPRSN-C Nº14, June 2001

Dosimetry and Biological Effects of Ionising Radiations



Dosimetry and Biological Effects of Ionising Radiations

Radiation Dosimetry is a major tool of radiation protection and for years the DPRSN has invested a significant effort in this area. Today, activities such as computational simulation of dose distribution in tissues are in development. The continued use of thermoluminescent dosimetry and film dosimetry, providing a backstop for most of the radiation workers in the country, reached a stage of Europe wide harmonization. New developments in the performance of individual thermoluminescent dosimetry may be expected as a result of the effort currently being made to update techniques in use and to introduce new dosemeter types.

Individual bio-monitoring, once a well established activity of DPRSN to ensure bio-assays of workers handling radioisotopes, may eventually be re-started using the Whole Body Counter. Significant progress was made in this area and full operation is expected for next year.

Radiobiology, encompassing research on the biological effects of ionizing radiation, expanded with studies on patients treated for thyroid cancer. Cytogenetic analyses gave significant contribution to the investigation of potential exposure of military staff to depleted uranium in the Balkans. Continued application of these techniques has been made also in the case of industrial workers exposed to ionising radiations.

Computational Methods in Radiation Protection. External and Internal Dosimetry

A.D. Oliveira and K. Jacob

Objectives

During the year 2001, we started new applications of the computer in radiation protection: The study of compartment models to describe the transport of radionuclides within the human body and in the environment. These models have applications in the Whole Body Counter (WBC) facility, which have being submitted to a repair of damaged and obsolete material.
We divided this group in two main areas: External dosimetry and internal dosimetry.

Results

External dosimetry.
Within this topic we concluded a PhD thesis. Extending the work of previous years, we used the Monte Carlo method, to introduce new methods in radiation physics and dosimetry. The spatial structure of energy deposition points from photons scattered in water and the introduction of the concept of radiation entropy are the main results of the work.
The topic of entropy became a very important aspect of the work. We found three different behaviours of the entropy for the deposited energy, very well related with the variation of the quality factor in the range of the energy studied (see figure). The entropy concept is a very simple way to describe the complex phenomenon of the degradation of the energy of a photon beam when interacting with matter. This is a field of study still in progress and we hope very fruitful.

Internal dosimetry.
The main facility used in this area is the WBC described elsewhere in this report. We started the study of compartment models from two points of view: the application in the WBC and also the application in the human contamination from the environment.

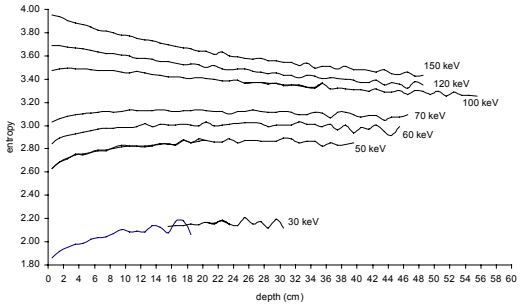


Figure: Entropy as a function of depth.

Published, accepted or in press work

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2. A.D. Oliveira and J.J. Pedroso de Lima, Dynamical analysis of data*, Proceedings of the 5th Portuguese Conference on Biomedical Engineering, in CD-ROM*, 2001.
3. A.D. Oliveira and J.J. Pedroso de Lima, Parallel perspective representation of three-dimensional points, *Proceedings of the 5th Portuguese Conference on Biomedical Engineering, in CD-ROM,* 2001.
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8. A.D. Oliveira, O método de Monte Carlo para fotões de energia entre 10 e 150 keV, *Radioprotecção,* Vol 1, Nº 8 and 9, Dec 2000 and May 2001.
9. A.D. Oliveira and J.J. Pedroso de Lima, The degradation of the energy of primary photons described through the entropy, *Proceedings of the Monte Carlo 2000 Conference in Advanced Monte Carlo for Radiation Physics, particle transport simulation and applications*, Lisbon 2000, editors A. Kling et al, Springer Verlag, Berlin Heidelberg New York, pp 425-430, 2001.
10. A.D. Oliveira and J.J Pedroso de Lima, The spatial structure of photons scattered in water, *Proceedings of the Topical Meeting on Medical Radiation Physics and Engineering*, Lisbon 2000, Physica Medica, in Press.

Whole Body Counter

A.D. Oliveira and K. Jacob

Objectives

The Whole Body Counter (WBC) is a well-known technique using spectrometry to measure the deposition of radionuclides within the human body and several organs like Thyroid or Lung, for example.
The main objective is to measure the internal contamination of human body. However, in the year 2001, the main activity was the repair of damaged and obsolete components, like all of the electronics, big metal structures with a motor to move the detector in front of the person under analyse and a new version of the canberra software for spectrometry. However, in spite of the great investment made in the repair, until to the end of the year it was not possible to acquire the calibration source, because of financial difficulties.

Results

Without calibration source we cannot have completely functional the WBC. Nevertheless, using an old radioactive source we tested the functionality of the installation. The test of functionality is fundamental, after the renewal of the equipment. We obtained good results in most of the tests, allowing us to begin using WBC, after the calibration of the detector and some smaller adjustment.
The WBC, existing in our department since 1990, is an Accuscan II with vertical linear geometry from Canberra. The facility first implemented have a low background, with one 25% germanium detector, using vertical scanning, and an interface with a VAX computer software for spectrum analysis.
Some important changes were made: new computer, with Windows NT, new motor controller, new electronic for spectrum acquisition and new software to perform the analysis. All system is now computer controlled using the Abacos 2000 software, which is part of the Genie 2000 family from Canberra specifically design for WBC applications.
One of the fulfilled objectives, was the training of the staff and trainees.
The Abacos 2000 has the flexibility to handle a wide variety of in vivo counting systems, including static and scanning modes and multiple acquisition geometries. At the moment we have defined four geometries for whole body, thyroid, lung and gastrointestinal. We have started to define the acquisition and positioning parameters for the four geometries and performed initial energy and efficiency calibrations. For the efficiency calibration we use the RMC II phantom (REMCAL Transfer Phantom) from Canberra. We were using a mixed gamma source but since the activity is too low, we are waiting for a new one to perform the final calibrations.
During this test period we also started to implement the quality control (QC) system. With the QC it's possible to control over time the performances of the system automatically.
The writing of an operation's manual is in progress. It can also be used as a guide for the routine and manual operations that can be done with the new setup.
This WBC system determines the amount of radioactivity present in the body at the time of measurement, but it cannot directly determine the amount present at some previous time. That quantity must be inferred from the measured body content and from the application of metabolic models or retention curves that describe the behaviour of the radionuclides in the body. The internal dosimetry is one of the objectives for the next year.

Harmonisation of Individual Monitoring in Europe

J.W. van Dijk[1], P. Ambrosi[2], T. Bolognese-Milsztajn[3], L. Currivan[4], R. Falk[5], E. Fantuzzi[6], M. Figel[7], J.G. Alves[8], M. Ginjaume[9], H. Janzekovic[10], V. Kamenopoulou[11], M.A. Lopez[12], M. Luszik-Bhadra[13], P. Olko[14], H. Stadtmann[15], C.M. Castellani[16], F. Vanhavere[17], E. Vartiainen[18], W. Wahl[19], A. Weeks[20] and C. Wernli[21]

Objectives

The aim of this EURADOS Working Group is the title itself: Harmonisation of Individual Monitoring in Europe.

The general objectives of the working groups are: to look at the continuing efforts of quality assurance programmes of the various dosimetry services, to discuss and initiate measures to improve the situation in this field, and to look at the new developments in instrumentation and testing.

Results

Four subgroups (SG) are currently working under this EURADOS project. Each is dedicated to the following subjects: SG1. – Implementation of standards; SG2. – Harmonisation policies for the integration of results from internal and external occupational exposure; SG3. – Electronic dosemeters for individual monitoring and other new developments; and SG4. – Quality assurance, quality control and reliability of dosimetric systems.

This project comes in line with the work developed under the former one Harmonisation and Dosimetric Quality Assurance in Individual Monitoring for External Radiation.

The main goal of SG1 is to go into more detail on standards and recommendations that directly deal with the dosimetric quality than the work developed previously, which was restricted mainly to aspects of legal approval.

A first draft entitled Implementation of Standards has already been produced by SG1, authored by 2, 6, 8 and 18, and is currently open for discussion and suggestions amongst all the members of the Working Group.

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Analysis of the Occupational Radiation Dose Data

J.G. Alves, M.B. Martins, A.R. Roda and P.C. Silva

Objectives

This work aims at the analysis of the occupational radiation dose for external exposure measured by the Individual Monitoring laboratories of ITN.

Results

In 2001 the Dosimetric Service monitored nearly 9700 workers from 890 facilities, corresponding to 57780 assessed doses, approximately. Currently at ITN-DPRSN there are two dosimetric systems operating simultaneously for individual monitoring, one is based on film dosimetry and the other one on thermoluminescence detectors. The assessed doses are kept in independent databases, one for each method of control. Preliminary results of 2000 data for the distribution of workers by effective dose intervals are shown in the following figure.

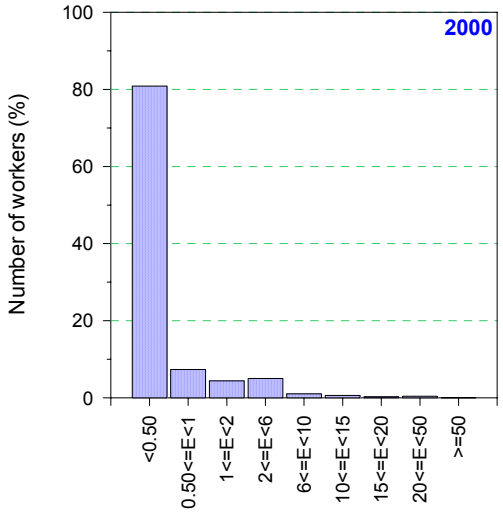

Fig 1 – Distribution of effective dose intervals (mSv) for monitored workers in 2000.

Occupational exposure in Portugal arises from four different fields of activity, namely: conventional industry, research laboratories, health and mining, since there are no nuclear power plants in the country.

Published, accepted or in press work

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Medical applications of radiation is the field of work that involves the largest number of persons both monitored and exposed, and the collective dose for the medical working field nearly doubled from 1994 to 1999, from 2.02 man.Sv to 3.99 man.Sv, respectively [1].

The results obtained in previous works (J.G. Alves et al. IRPA-10 (2000) and [1]) suggest: 1. a closer review of the measured dose values is needed; 2. dose distributions should be correllated to the type of work (professions); and 3. the identification of the practices that give rise to the higher doses are also needed.

In order to seek these objectives, a questionnaire was prepared and sent to all the monitored installations. New facilities applying for dosimetric evaluation are also requested to fill in the questionnaire.

The responsible is to provide information on the facility (medical applications, industrial apllications, research and training and natural radiation exposure), and on their main activities.

Relative to the workers, each installation is suppposed to provide a list with enough information so that it is possible to establish a link between an individual and the respective profession and practice.

The most frequent activities, professions and practices have been included in the questionnaire, allowing for a quick response to the inquiry.

A new database has been created for the insertion of the collected information and presently, nearly 70% of the facilities have already answered back and their data have already been updated.

Relative to the total number of workers this corresponds to approximately 65% of the monitored population data.

Occupational exposures measured in the period 1974 to 1991 by film dosimetry have been inserted in database format.

Modifications have also been introduced in the database used in film dosimetry in order to harmonise the dose reports issued by both services.

Improving the Performance of the DPRSN TLD-Individual Monitoring System

J.G. Alves, V.I. Batel and P.C. Silva

Objectives

This work aims at introducing improvements in the routine work of Individual Monitoring with thermoluminescent detectors.
It also aims at the implementation of methods for continuous analysis of the parameters influencing the quality of the measurements.

Results

The TLD system used at DPRSN for Individual Monitoring is comprised of two 6600 Harshaw automatic readers and on the Harshaw 8814 TL card and holder containing LiF:Mg,Ti (TLD-100) detectors for the evaluation of $H_p(10)$ and $H_p(0.07)$.
Detectors normally issued to outside customers are routinely read interspaced with quality control dosemeters, e.g. dosemeters pre-irradiated always to the same reference dose and zero dose detectors that have never been irradiated. Simultaneously, as part of the reading programme, the TL reader periodically performs readings of the reference light source and of the PMT noise. A database routine has been developed to automatically perform the evaluation of the readings related to the quality control detectors, the reference light source and the PMT noise. The sensitivity of the reader is followed and corrected by the output of the quality control detectors. Comparisons can be established with the results of the internal check-up. The database routine automaticaly displays the results on table and on a quality control chart for direct visualisation.
As part of a quality assurance programme, regular performance tests to the system have been introduced, and can be described as folows. Every monitoring period two groups of dosemeters are issued to the DPRSN-Standard Dosimetry Laboratory: one is composed of 20 dosemeters that are irradiated to known doses of 0.10, 0.50, 1.00, 5.00 and 10.00 mSv; the other one is composed of 12 dosemeters that are irradiated to unknown radiation qualities, irradiation geometries and unknown doses, corresponding to a "dummy customer".
Linearity, coefficient of variation and reproducibility checks are thus periodically being carried out.
Natural radiation dose is also evaluated in the premisses of the service, in areas where mailing, reading and storage of detectors take place.
Each monitoring period the limits of detection and of determination are evaluated using Hirning's expressions (Health Phys 62(3), 1992). Storage of the above mentioned parameters are allowing for the determination of acceptance, action and rejection levels on quality control charts.
The "dummy customer" results are allowing a periodic evaluation of the service's overall performance since the dosemeters are treated, read and their dose is evaluated under normal routine procedures.
The influence of annealing procedures is being evaluated as a function of dose and of the evolution of the residual signal.
Type testing and overall uncertainty evaluation are being performed using the following radiation qualities N25, N30, N60, N100, N150, ^{137}Cs and ^{60}Co, according to the ISO Standard Series 4037 and the Technical Recommendations of the European Commission EUR 14852. Slab and water phantoms have been used for all the radiation qualities and irradiation geometries mentioned.
All the important procedures normally used in routine work and that may contribute to the quality of the service are gradually being written down.
Quality control charts for the long-term evolution of the most important parameters are being prepared, along with the determination of acceptance, action and rejection levels.
Manuals for the periodic changes of the databases used and a collection of the necessary procedures of the Individual Monitoring service are being prepared.

Published, accepted or in press work

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Gamma Radiation: Population Doses

E. Amaral

Objectives

The Portuguese population exposure to ionising radiation is under study since 1985 and now attention is focused to the reassessment and interpretation of natural gamma radiation levels in different country regions, as natural radiation is the main source to collective dose for world population, due to external or internal sources (UNSCEAR, 1988).

This work intends to update the actual statistics of gamma radiation doses, as the population has changed in different ways in the last ten years, decreasing in several councils of northern interior or increasing by migration to more atractive councils. During these years the Portuguese population increased 4.6%, surpassing ten million inhabitants. This situation demands a new analysis establishing the population distribution in country, in order to assess the outdoors and indoors exposure rates in air per council.

Results

A new analysis establishing the population distribution in the country, the absorbed dose rates in air, respective averages and ranges is now completed in 117 councils in the country. This assement continues for the remainder councils, to establish a radiological map.

Our 1st survey was meant to assess natural gamma radiation doses outdoors at previously selected sites in different country regions, where low background was expected. Soil nature and population statistics were also taken into account in several surveys.

Meanwhile, a request has come by the United Nations Scientific Committee on the Effects of Atomic Radiation in order to establish the effective dose rates, also agreeing with 2001 population data classified by dose intervals. Another request is the identification of discrete sub regions of high background in the country that we intend to examine.

Radiobiology

J.H. Pereira Luís, M.L. Pedro and M.J. Figueiredo

Objectives

Evaluation of the genotoxic damage as a result of exposure to ionizing radiation in professionally exposed workers and in the case of accidents.

Results

In professionally exposed workers or in an accident, as a consequence of the exposure to ionizing radiation, late biological effects may arise. Among the most serious late effects is the cancerigenesis. On one hand, epidemiological studies reveal that the populations exposed in Hiroshima and Nagasaki show a higher cancer incidence and, on the other hand, experimental studies show that radiation leads to genotoxic lesions, DNA instability and chromosomic breaks and mutations.

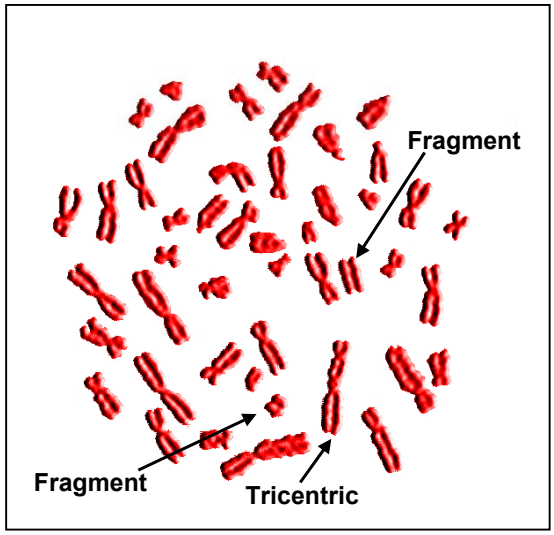


Fig.1 Metaphase cell, from peripheral blood lymphocytes of an individual accidentally exposed, with chromosomal damage showing chromosome breaks and chromosomal recombination. Two fragments and a tricentric are observed.

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. In one accident case, in which the dose given by physical dosimetry was insignificant, a high chromosomal aberration frequency was observed, hence inferring the existence of risk due to exposition. Although observed in two cases some chromosomal aberrations and a high incidence or chromatidic aberrations, professionally exposed workers analysed cannot be considered to be submitted to a higher risk for the development of cancer.

Some of the analyses previously made to professionally exposed workers were also made to military and civil individuals. Three of them showed a high number of chromosomal and chromatidic breaks. Ionizing radiation is a known apoptosis inductor in human lymphocytes and the degree of radioinduced apoptosis may be an indicator of genome aggression.

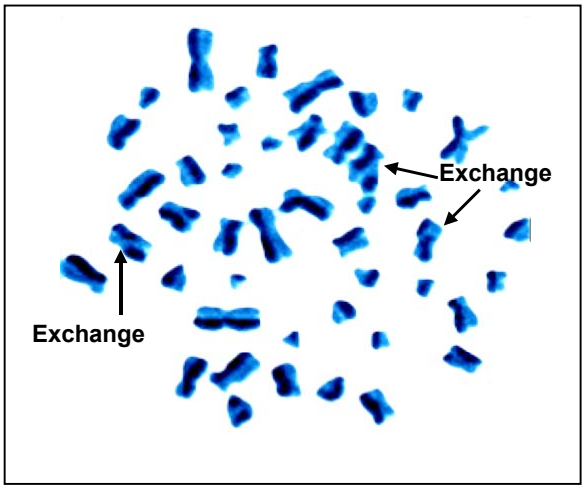


Fig.2 Metaphase cell in 2nd division, from peripheral blood lymphocytes of an individual accidentally exposed, showing chromosomes with the chromatids differentially stained. Exchanges between sister chromatids are observed.

In order to increase the information about the lesions resulting from the ionizing radiation exposure, it has been developed a technique that provides data about the cells undergoing apoptosis. The DNA internucleosomal fragmentation detected by quantitative methods based on cell death detection ELISA, has been selected as a biological index to the evaluation of radioinduced apoptosis in peripheral human lymphocytes. The first assays to optimise the method have already been done.

Study of Glutathione S-transferase polymorphisms in thyroid cancer patients

Octávia Monteiro Gil

Objectives

The aim of this study was to evaluate, in a population with thyroid cancer the role of Glutathione-S-Transferases (*GSTM1, GSTT1* and *GSTP1*) polymorphisms in the susceptibility for this type of cancer.
We conducted a case-control study to evaluate the potential role of the *GSTM1* and *GSTT1* null genotypes and *GSTP1* (codon 105 ile→val) polymorphisms in thyroid cancer (papillary and follicular) patients.

Results

Thyroid cancer patients (103) were from the Nuclear Medicine Department of the Portuguese Oncology Institute of Lisbon, and case control population (204) (with no thyroid pathology) were from São Francisco Xavier Hospital.
The frequency of *GSTM1* and *GSTP1* null genotype is consistently increased in papillary thyroid cancer, when compared with follicular tumours.

For the frequency of *GSTP1* genotype (cd 105 ile→val) in control and cancer population there were no significant differences between the two populations studied.
The results obtained show that individuals with a particular combination of genotypes (*GSTM1*0, GSTT1**0, *GSTP1ile/ile*) have a significant risk increase for thyroid cancer, and particularly for papillary tumours.
The results obtained show that the association of different *GST* polymorphisms leads to an increased predisposition for thyroid cancer and that *GSTP1* polymorphisms could also modulate the age of onset of the disease.

Published or in press work

1. J.Gaspar, S.Rodrigues, O.Monteiro Gil, I.Manita, T.C.Ferreira, J.Esperança Pina, E.Limbert, J.Rueff, Glutathione S-Transferase GSTM1, GSTT1 and GSTP1 polymorphisms and thyroid cancer risk. *Human Genetics and Genomics, Keystone Symposia, Abstract Book* (2001), pp 65.
2. O.Monteiro Gil, N.G.Oliveira, A.S.Rodrigues, A.Laires, T.C.Ferreira, E.Limbert, J.Rueff, Lymphocytes from iodine-133 treated thyroid cancer patients undergo a transient adaptation towards mitomycin C genotoxicity, *Genetic Susceptibility at low dose exposure, 31st Annual Meeting of the EEMS, Ghent, Proceedings Book* (2001), pp 166.

Support to the Implementation of a Radiation Protection System in Portugal

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

Objectives

It is widely recognized, including in the Decree-Law 311/98 of 14 October, that Portugal lacks the implementation of a national regulatory authority in radiation protection. The country stays far behind the adoption of the International Basic Safety Standards in Radiation Protection of workers and the general public. A cooperative regional project was set up with the support of the IAEA, to improve the current situation and to enhance awareness namely about Regulatory infrastructures set up in other countries, to train a new generation of personnel in radiation protection, and to adapt regulations and practices to international standards.

Results

Under this IAEA project two expert missions were carried out to Portugal. One, in March, to discuss with ITN and the Directorate General for Health the current situation of Portuguese legislation on radiation safety, control of radiation sources, management of radioactive waste and, mainly, for the identification of a natural regulatory authority in radiation protection. Another mission was carried out in September by an expert from Germany, Federal Bureau of Radiation Protection, for discussions with Environment and Health Authoritiesand ITN, on the international safety standards and the adoption of the EU Directives 29/96 Euratom and 43/97 Euratom on radiation protection. The transposition of these Directives, entrusted to the Directorate General of Health of Ministry of Health, has not been done as yet.

In the framework of this project training opportunities abroad were offered by the IAEA. Eight (8) trainees, most of them young fellows at ITN, were sent abroad as participants in six (6) education and training actions of 1-2 weeks duration each, covering fields such as Transport of Radioactive Materials (internal and external) Occupational Dosimetry, Radiation Protection in Radiology, amongst others.

Two national training courses (1 week duration each) on radiation protection for industrial radiography and for radiodiagnostic were organized by the DPRSN. Lecturers from other countries were invited to teach in these courses.

This project is supported by the AIEA Contract RER/9/062.

Published, accepted or in press work

1. F.P. Carvalho. Protecção Radiológica do Homem e do Ambiente: Necessidade de um Sistema Coerente. *Radioprotecção,* Vol I, 8-9*,* 2001, 159-164.
2. National Training Course on Radiation Protection in Industrial Radiography.
3. Training Course Manual on: National Training Course on Radiodiagnostic and Interventional Radiology.
4. F.P. Carvalho. The Current Situation of the Regulatory Authority and Radiation Protection and Safety of Radioactive Sources in Portugal. Relatório DPRSN B, Nº. 14 (2001). ISBN: 972-95401-7-9

Control of Radioactive Sources and Waste Management

Control of Radioactive Sources and Waste Management

Romão Trindade

The Control of Radioactive Sources and Waste Management Group (GCFRGR) continued the development of the activities that have been mentioned in the previous Annual Report (2000).
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 GCFRGR. Among them, the main fields of intervention are:

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 and Ministerial Order nº 17018/2000 (2ª Série). Data from previous years related to the clients' identity and wastes characteristics started being storage in computer in a database developed by the Group. About 150 requests for radioactive waste collection including spent sealed sources were received during 2001.

The licensing of sealed sources for industrial, research, medical or other applications, regulated by Decree Law nº 153/96 of Ministry of Enviroment, showed in 2001 a clear increase in the number of requests. Several processes were throughly analyzed by the Group staff and about 190 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 been another of the activities of the Group. The monitoring of radioactive materials from the RPI to other countries, natural uranium cargo being exported and 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. An incident at a medical and research institute and another at an industrial facility showed the extreme importance of the correct application of the Radiological Protection Principles. The intervention of GCFRGR 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, it was impossible to develop research activities. However, it should be pointed out the fact that the Coordinator of Radiological Protection and Radioactive Waste Management Group was invited to participate in an European Project in the Fifth Framework Programme entitled "Risk Assessment and Environmental and Health Impact of Depleted Uranium Containing Ammunitions and Other Matrices".

The GCFRGR is involved in the following Technical Committees: Commmunity Plan of Action in the Field of Radioactive Waste (ACPM); European Waste Regulator Forum (EWRF); Radioactive Substances Committee of Oslo and Paris (OSPAR); Standing Working Group on Safe Transport of Radioactive Materials (TRAM); National Committee for Transport of Dangerous Goods (CNTMP). This Group has also participated with comments for the Eurobarometer Public Opinion Survey on Radiaoctive Waste and for the Fifth Community Situation Report on Radioactive Waste and Questionnaire.

The GCFRGR 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.

Metrology of Ionising Radiations

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).

The work made during 2001 can be summarized as follows:

The relevant activity was the participation in the international process leading to the mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology laboratories.
As a national metrology laboratory for ionising radiations – under a protocol with the Portuguese Institute for Quality - we prepare all documents required to apply for the recognition of a 43 calibration services available in our laboratory. Discussions of technical aspects of proposed services were carried out between 17 European laboratories under the coordination of EUROMET. These discussions last until a multilateral agreement was reach in November 2001.
The arrangement for the mutual recognition 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.

Our laboratory contributed to EUROMET Project 512 through the direct participation of the Portuguese Institute for Quality. For this purpose it was prepared a Quality Manual and written technical and administrative procedures according to ISO 17025.
An internal audit was carried out and conclusions and recommendations are now being used to improve the system.

Technical support was provided to 3 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 and 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.

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).

LMRI is carrying out the implementation of the QS according ISO 17025. Quality Manual was prepared and approved by ITN and DPRSN directors. Technical procedures were written for many calibration services and an internal audit was carried out. Final stages of these projects will occur next year.

Experimental Determination of the Radiation Protection Quantity, Personal Dose Equivalent, $H_p(10)$

J. Cardoso and A.F. Carvalho

Objectives

Construction and technical study of an ionization chamber prototype, that will be a secondary standard, to measure the conventional true value of the quantity personal dose equivalent, $H_p(10)$, at 10 mm deep.

Results

The ionization chamber was constructed complying with the standards ISO 2768-1 and ISO 2768-2. These international standards deal with the geometrical construction tolerance of assembled parts.
Besides the manufacture of parts in ITN workshop, it was necessary apply the electrodes and establish the electrical connections between the electrodes and the low noise electrical cables. These connections were made from a mixture of graphite powder and epoxy resin. They were tested in what concerns the electrical resistance for the expected value of electrical current.

The ionization chamber will be studied in beams of x-rays and gamma radiation. For this purpose a beam of x-ray, quality N-30, was checked, by determining half-value layer (HVL) versus potential and tube filtration. Those parameters, that characterize x-ray radiation quality, shall comply with the international standard ISO 4037-1, that deals with radiation characteristics and production methods.
In order to improve and validate the experimental results, the effects of variation in the dimensions and geometry of the ionization chamber, will be testing by computational simulation with the Monte Carlo N-particle Code. This work intends to simulate the ionization chamber and the ICRU sphere, where the quantity is theoretical defined, and from these results, it is expected to make optimization of the ionization chamber response.

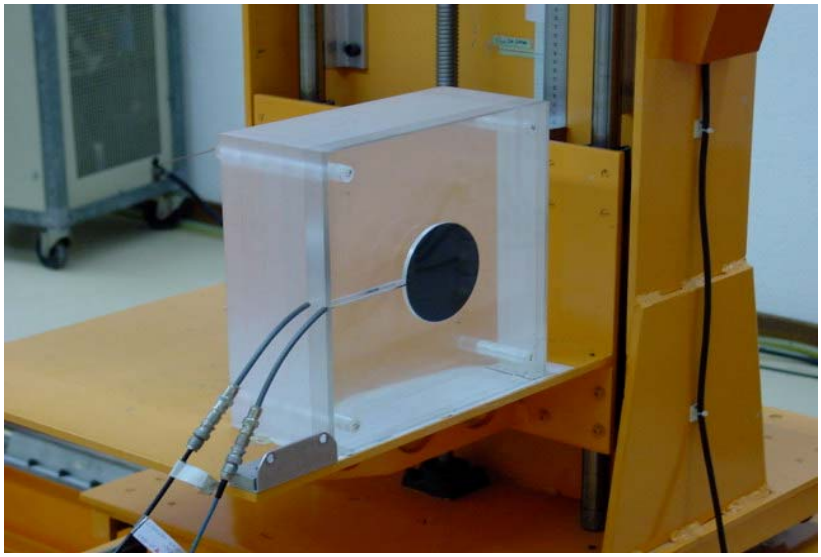


Fig. Ionization chamber for direct measurement of $H_P(10)$.

Services

I. Environmental Radioactivity

1. Radioactivity in Drinking Waters

G. Ferrador, M.M. Sequeira, V. Silvino, I. Lopes, M.A. Tavares, A. Pereira

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 220, global alpha and beta, and 60 tritium measurements were performed during 2001.

2. Natural Radioactivity in Mineral Waters

G. Ferrador, I. Lopes, M.A. Tavares

In order to obtain license to the commercialisation of mineral waters, an evaluation of the radioactive levels (^{226}Ra concentration and global beta activity) should be performed (Decree-Law nº84/90). Several enterprises and the National Authority of the sector often request by this radiological study.
A total of 34 analyses were performed during this year.

3. Natural Radioactivity in Spas Waters

M.C. Faísca, G. Ferrador, J.M. Oliveira, P. Duarte, C. Pires

Request by "Termas Sulfurosas de Alcafache, S. A." an evaluation of the natural radioactivity for monthly samplings in three different springs were performed. Analyses of global alpha and beta activities, ^{226}Ra, radon, uranium, thorium and plutonium were carried out.
Analyses of global alpha and beta activities and ^{226}Ra were performed at "Termas do Crato" spas waters requested by the Municipality Authority.

4. Radiological Survey of Residual Waters of Instituto Português de Oncologia (IPO)

A.Brogueira, M.M. Sequeira, C. Pires, M.A. Pereira, V. Silvino

A radiological survey of residual waters from IPO has been carried out since 1996 concerning artificial radioactivity. IPO technicians have performed monthly sampling of residual waters in several retention reservoirs before the IPO outlet. These samples are analysed by quantitative and qualitative gamma spectrometry at the DPRSN. Gamma spectrometry is carried out using GeHP detectors. This radiological survey is performed by request of the Instituto Português de Oncologia.

5. Natural Radioactivity and Radon Exhalation from Building Materials

M.C. Faísca, P. Duarte, C. Pires

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

6. Indoor Radon

M.C. Faísca, P. Duarte

By request indoor radon measurements were performed in buildings.
Participation in the 2001 Intercomparison of passive Radon Detectors coordinated by the National Radiological Protection Board (NRPB), U.K.

7. Application of Radon Exhalation in Hydrogeology

M.C. Faísca, P. Duarte

A study of radon exhalation has been performed 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. Câmara Municipal de Nisa requested this study, with supervision of the technical Director of the spring area. It has consisted in a radon exhalation rate survey in an area of about 20 hectares around the spring, allowing the detection of the higher permeability zones. To accomplish this survey soil gas sampling was performed in 36 sites.

8. Artificial Radioactivity Levels in Foodstuffs and other Samples

M.C. Faísca, C. Pires, R. Rodrigues, M.A. Tavares

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 (gamma spectrometry analysis, and ^{90}Sr determinations) in order to determine concentrations of artificial radionuclides. During this year 30 samples were analysed.

II. Dosimetry and Biological Effects of Ionising Radiations

1. Specialized Cytogenetic Analyses

J. H. Pereira Luís, M. L. Pedro and M. J. Figueiredo

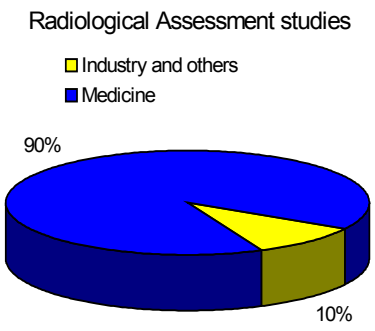
During the year 2001 several specialized cytogenetic analysis were done. The analyses were used to identify biological damage at chromosomal level induced by ionizing radiation or by other environmental aggressors. This type of analysis was also used to estimate the radiation dose by biological dosimetry.

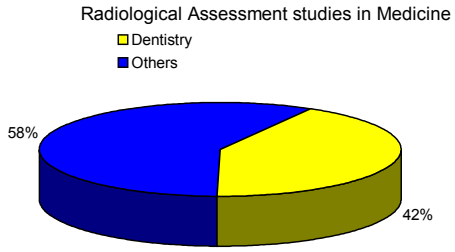
Type of analysis	N^r analyses
Chromosome aberration	34
Sister Chromatid exchange	10
Micronucleus	10

2. Radiological Safety Assessment

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

The main activity in this field is a technical service making reports in radiological safety assessment. The General Directorate of Health of the Ministry of Health requests most of the services. Those reports are used for licensing of radiological installations accordingly the Decree-Law Nº 348 and Regulamentar-Decree Nº 9/90. Nevertheless we make also inspection by direct request of the owners of the installations. Most of the activity in this field is services, but we make an effort to implement new methods, like the introduction of new software packages and stay up-to-date with the state of the art in radiation shielding and radiological assessment. The risk assessment is a complex and time consuming subject, which needs more time and human resources to decrease timings in the response to the requested services and to improve the development of high level methodologies. This year there was an increase in the number of studies in dental radiology, as we can see in the pie chart for studies in Medicine. During 2001, 400 studies were requested.





3. Individual Monitoring of External Radiation

At DPRSN there are two on-going control methodologies for the Individual Monitoring of External Radiation, one based on film and the other on thermoluminescence dosimetry (TLD).

3.1 Film dosimetry

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

The personal dosemeter used for the measurement of X ray and gamma radiation is based on a Kodak type II film inserted on a homemade holder, which is changed on a quarterly basis.
In 2001 about 3,240 workers from 287 facilities were controlled corresponding to approximately 12,900 assessed doses. In Figures 1 and 2 the number of monitored workers and facilities grouped by different fields of activity, namely, health, industry and research laboratories, are displayed.

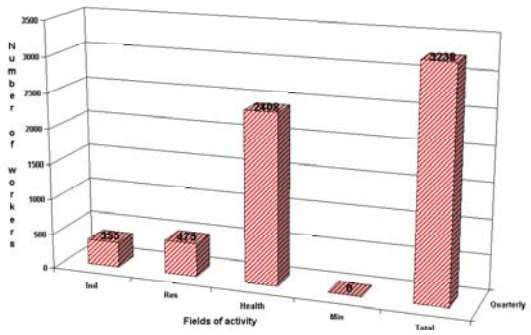


Fig. 1 – Number of monitored workers grouped by field of activity.

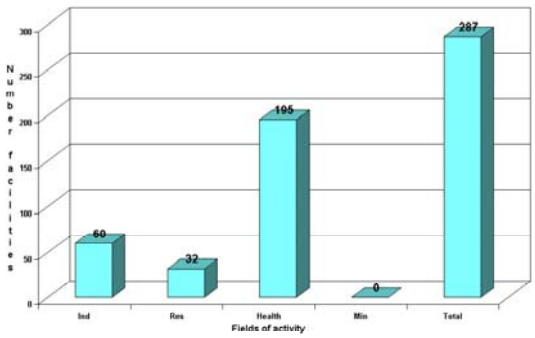


Fig. 2 – Number of facilities grouped by field of activity.

3.2 Thermoluminescence dosimetry

J.G. Alves, J.V. Monteiro P.C. Silva, D.J. Miranda, S.B. Rosa, S.S. Rangel, V.I. Batel (left September 1st).

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 $H_p(10)$ and $H_p(0.07)$, the personal dose equivalents at the depth of 10 and 0.07 mm, respectively.
In 2001, 6,460 workers from 600 facilities (approx.) 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 3 and 4.

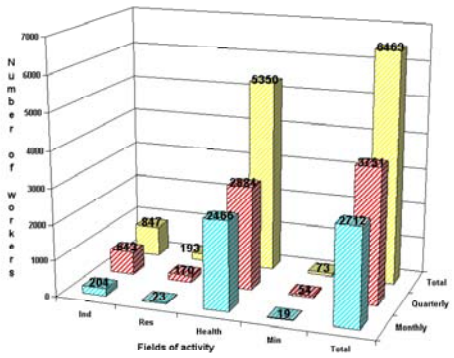


Fig. 3 – Number of monitored workers grouped by field of activity and monitoring period.

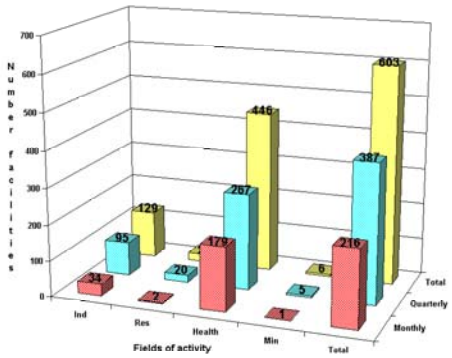


Fig. 4 – Number of facilities grouped by field of activity and monitoring period.

In 2001, about 9,700 workers from 890 facilities were controled on a monthly or a quarterly basis, corresponding to 57,780 assessed doses (approx.).
The total number of assessed doses in 2001 using both Film and Thermoluminescence dosimetries are displayed in Figure 5. Data for each monitoring period are also presented.

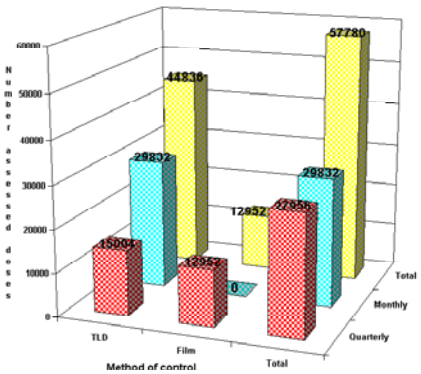


Fig. 5 – Total number of assessed doses in 2001.

III. Control of Radioactive Sources and Waste Management

1. Radioactive Waste Management

R. Trindade, L. Portugal, M.I. Paiva, F. Teixeira, R. Casquinha, M. E. 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 150 requests for radioactive waste collection were received.

2. Control of Radioactive Sources

a) Licensing of Sealed Sources

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

According to Decree-Law nº 153/96, 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 190 licenses were issued.

b) Radioactive Cargo in Transit

R. Trindade, L. Portugal, M.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 19 ships called Lisboa harbour.

c) Scrap Metal

R. Trindade, L. Portugal

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

d) Nuclear Vessels

L. Portugal, R. Trindade, A. Brogueira, C. Pires, M.I. Paiva, P. Duarte, M.A. Tavares, R. Casquinha, H. Guerreiro, R. Rodrigues, V. Silvino

An environmental radioactivity survey was 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 collected for gamma spectrometry analysis. Sampling was done before, during and after the stay of the vessel. Results are reported to Ministry of Defence. Only one nuclear vessel stayed near Lisbon harbour this year.

e) Surveillance of ITN Campus

R. Trindade, L. Portugal, A. Brogueira, C. Pires, R. Pombo, L. Brás, M.C. Faísca, M. Reis, M.A. Tavares, J. Alves

Surveillance of radioactivity in liquid effluents from RPI, Chemistry Sector and Central Tanks. The results are reported to the Radioactive Substances Committee of OSPAR Convention.
Periodical surveillance of radioactivity in aerosol, grass and rainwater samples in order to control gaseous releases due to the operation of RPI.
Permanent control with TLD´s of environmental radiation dose in two locations in Campus.

f) Smuggling of Nuclear and Radioactive Materials

R. Trindade, M.I. Paiva

Collaboration with the Portuguese Criminal Police on detection and identification of suspected smuggling of nuclear or radioactive material into the Portuguese territory.

g) Others

R. Trindade, L. Portugal, M.I. Paiva, R. Casquinha

During the year 2001 several monitoring actions were carried out to verify contamination and radiation levels, the compliance with international rules related with transport of radioactive material, consulting services, etc. at:

- Escola de Limitação de Avarias, Base Naval do Alfeite
- Instituto Português de Oncologia Francisco Gentil, Lisboa
- DAI, Fábrica de Açúcar de Beterraba, Coruche
- ELA building, Base Naval do Alfeite
- Depósito da Direcção de Abastecimento, Base Naval do Alfeite
- Alstom, Setúbal
- Esquadrilha de Helis da Marinha, Base Aérea do Montijo
- Prolixo, Barreiro
- Transport of natural uranium to export, Urgeiriça
- Transport of packages from RPI, ITN, Sacavém
- Experimental Unit at UTR, ITN, Sacavém
- Instituto Nacional de Saúde Pública Ricardo Jorge, Lisboa

IV. Metrology of Ionising Radiations

A.F. 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 of 21 July. Metrological control includes calibration and type testing. During 2001 were calibrated 50 dosimeters and perfomed type testing of 1 dosimetric system of Armed Forces. About 500 TLD dosimeters were irradiated.

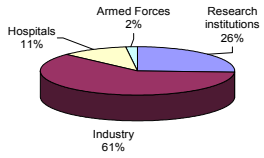


Figure 1: Instruments calibrated by user's activity

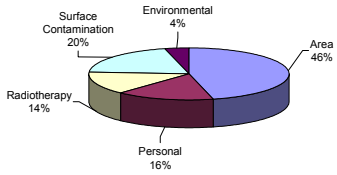


Figure 2: Instruments calibrated by monitoring type.

V. Medical Office

- Occupational Medicine

- Curative Medicine

- Clinic Pathology Laboratory

J. E. Ribeiro e Costa, M.F. Fragoso, H. Santos

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;

- Clinical medicine, as a complementary service to ITN workers;

- Laboratorial medicine as support to the occupational medicine and clinical medicine;

- Education in medical and biological aspects of radiation protection and medical advise in case of over-exposure.

The number of medical examinations and clinical analyses performed in 2001 are presented in the following table:

1. Clinical analyses: Total number of analysed parameters		**1261**		
		ITN	**EXTERNAL**	**TOTAL**
2. Medical examinations				
2.1. Per-placement health examinations		15	-	15
2.2. Periodical health examinations		103	50	153
2.3. Work cessation health examinations		9	-	9
2.4. Occasional health examinations		878	-	878
	TOTAL	**1005**	**50**	**1055**
3. Post transfers		7*	-	7
4. Visits to work places		9	-	9
5. Occupational injuries registered in the Individual Process		4	-	4

* Temporarily