Coordinated Research Activities

Annual Report and Statistics for 2011

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Coordinated Research Activities

Annual Report and Statistics for 2011

Main Document

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EXECUTIVE SUMMARY

The Annual Report and Statistics for 2011 of the IAEA's Coordinated Research Activities has been re-designed into 2 documents: the ***Main Document*** and the S***upplement***. The *Main Document* contains main figures and statistics on the Coordinated Research Activities Budget, the Contracts and Agreements, the Member State Participation, Coordinated Research Projects Completed in 2011 and the Evaluation for Completed CRPs. A chapter on **Coordinated Research Activities Achievements in 2011 by Thematic Sector** has been added to illustrate some successful Coordinated Research Projects (CRPs) that have either been completed or evaluated in 2011. The *Supplement* contains detailed information on CRPs, Contracts and Agreements and Research Coordination Meetings.

In 2011, a total of €6 713 897 were obligated for the IAEA's Coordinated Research Activities (€6 539 145 from the regular budget and €174 752 from extrabudgetary resources). Most of the Coordinated Research Activities are carried out via Coordinated Research Projects (CRPs) which bring together research institutes in both developing and developed Member States to collaborate on research topics of common interest. At the end of 2011, work was being carried out on 130 CRPs, as referenced in the *Supplement*, Chapter A.I of this report.

1012 research, technical and doctoral contracts and 655 research agreements with institutes in 106 Member States were operational at end 2011. 89% of the funds obligated for contracts in 2011 were in respect of institutes in developing countries or countries in transition, primarily in the areas of food and agriculture and human health.

During 2011, 25% of the Chief Scientific Investigators participating in IAEA CRPs were female researchers. Efforts will continue to increase the participation of women and younger researchers in the Coordinated Research Activities.

1. INTRODUCTION

Article III of the IAEA Statute authorizes the IAEA to encourage and assist research on, and development and practical application of, atomic energy for peaceful purposes throughout the world and to foster the exchange of scientific and technical information, as well as the exchange of scientists in the field of peaceful uses of atomic energy. The IAEA's Coordinated Research Activities stimulate and coordinate the undertaking of research in selected nuclear fields by scientists in IAEA Member States.

The IAEA supports research under its programmes, subprogrammes and projects that are listed in its approved Programme and Budget. These Coordinated Research Activities are normally implemented through Coordinated Research Projects (CRPs) which bring together research institutes

in both developing and developed Member States to collaborate on research topics of common interest. Research, technical and doctoral contracts and research agreements are awarded to institutes in Member States for their completion of research work under these CRPs. The IAEA may also respond to proposals from institutes for participation in the research activities under individual research contracts not related to a CRP. A small portion of available funds is used to finance individual projects, which deal with topics covered by the IAEA's scientific programme.

The IAEA also supports doctoral CRPs, which are designed to strengthen promotion of research on nuclear technologies in developing Member States through pair building between agreement and contract holders. These CRPs include a PhD training programme at the contract holders' institutes. Two doctoral CRPs are currently implemented by the Human Health programme. One addresses the Quality Assurance of the Physical Aspects of Advanced Technology in Radiotherapy and the other deals with the assessment of human milk intake and body composition of infants and young children up to two years of age.

Further information on the IAEA's Coordinated Research Activities, including current information on CRPs and supported programme areas, participation of institutes in Member States, as well as information on policies and procedures and the management of the activities is available on the IAEA's Coordinated Research Activities website:

http://cra.iaea.org/

2. COORDINATED RESEARCH ACTIVITIES IN SUPPORT OF IAEA PROGRAMMES AND SUBPROGRAMMES

The active Coordinated Research Activities reported in this document are conducted in support of the following IAEA programmes and subprogrammes.

Programmes		**AIPS Prog. No.**	**No. of Active CRPs**
Major Programme 1: Nuclear Power, Fuel Cycle and Nuclear Science		1010000	**37**
Programme 1.1 (A.)	Nuclear Power	1010002	9
Programme 1.2 (B.)	Nuclear Fuel Cycle and Materials Technologies	1010028	3
Programme 1.3 (C.)	Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development	1010041	3
Programme 1.4 (D.)	Nuclear Science	1010058	22
Major Programme 2: Nuclear Techniques for Development and Environmental Protection		2010000	**85**
Programme 2.1 (E.)	Food and Agriculture	2010003	31
Programme 2.2 (F.)	Human Health	2010024	33
Programme 2.3 (G.)	Water Resources	2010054	7
Programme 2.4 (H.)	Environment	2010065	3
Programme 2.5 (I.)	Radioisotope Production and Radiation Technology	2010088	11
Major Programme 3: Nuclear Safety and Security		3010000	**8**
Programme 3.2 (J.)	Safety of Nuclear Installations	3010013	2
Programme 3.4 (L.)	Management of Radioactive Waste	3010048	3
Programme 3.5 (M.)	Nuclear Security	3010062	3

The Programme/Subprogrammes and the Corresponding CRP Codes are listed in the *Supplement*, Part D.

Results of the research are available to all Member States and are disseminated through national, international and IAEA scientific and technical publications. The Coordinated Research Activities are complementary to the IAEA's Technical Cooperation Projects, with the knowledge gained via coordinated research used to enhance the quality of Technical Cooperation Projects. Some research results are directly relevant to Technical Cooperation Projects and lead to successful implementation of these projects, while some Technical Projects lead to participation in Coordinated Research Activities. In addition, CRPs and TC Projects may also be carried out simultaneously.

3. COORDINATED RESEARCH ACTIVITIES IN 2011

Work on 130 CRPs was being carried out at the end of 2011. 37 in Major Programme 1 – Nuclear Power, Fuel Cycle and Nuclear Science, 85 in Major Programme 2 – Nuclear Techniques for Development and Environmental Protection, and 8 in Major Programme 3 – Nuclear Safety and Security. Although the total amount obligated for these activities in 2011 (€6 713 897) decreased in comparison with the amount in 2010 (€7 108 183), 10 additional CRPs were being carried out in 2011. In terms of benefits to Member States through their participating research institutes, number of awards and degree of funding, the Coordinated Research Activities constitute a significant component of the IAEA's overall programme.

3.1. Coordinated Research Activities Budget

In 2011, the IAEA obligated a total of €6 713 897 in support of research projects under its Coordinated Research Activities. Of this total amount 72% (€4 864 315) was used to finance contracts and CRP purchases and 28% (€1 849 582) was used to finance 73 Research Coordination Meetings (RCMs) held every 12 - 18 months during the life of a Coordinated Research Project (CRP).

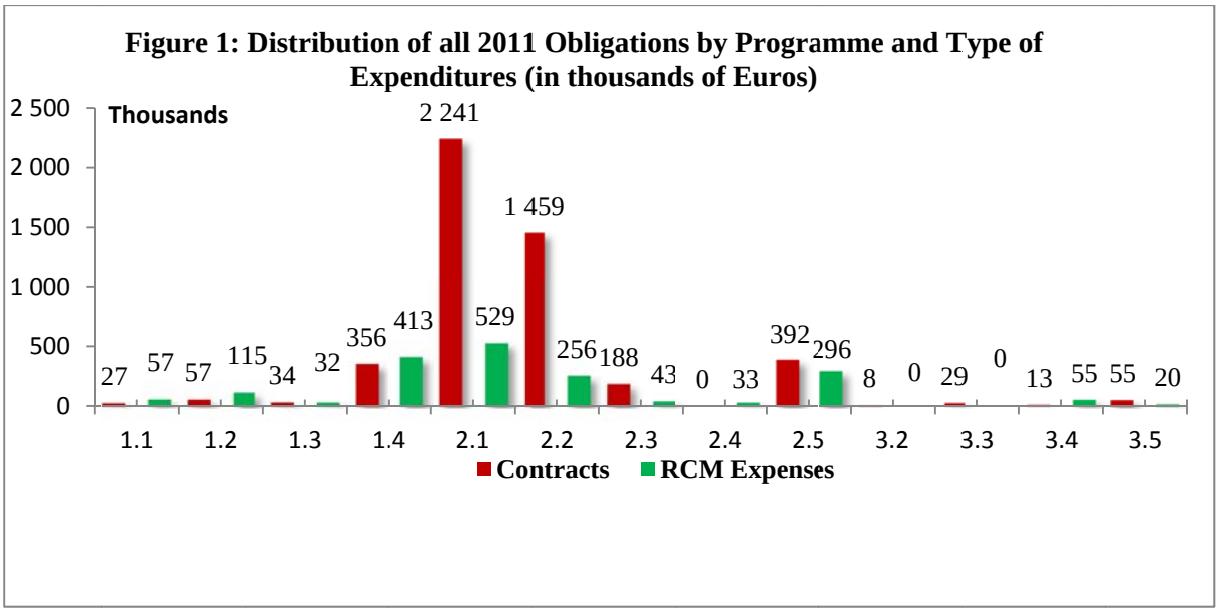
At the end of 2011, there were 130 active CRPs, the majority thereof in Major Programme 2 (see *Supplement*, Chapter A.I). An additional 21 CRPs had been approved, but were not yet initiated. A list of these CRPs can be found in the *Supplement* Chapter AII. Total obligations amounted to €1 091 267 in Major Programme 1, €5 443 906 in Major Programme 2 and €178 724 in Major Programme 3.

TABLE 1 on page 5 provides a summary of the funds obligated by programme in 2011 and FIGURE 1 on page 6 reflects the Distribution of all 2011 Obligations by Programme and Type of Expenditure (in thousands of Euros).

Table 1: Summary of Funds Obligated (in Euro) by Programme in 2011

Programme	Regular Budget Funds (RBF)				Extra Budgetary Resources (EBR)				RBF+EBR
	Contracts	CRP Purchases	RCM Expenses	Total by Programme	Contracts	CRP Purchases	RCM Expenses	Total by Programme	Total by Programme
1.1 Nuclear Power	27 000	0	57 418	84 418	0	0	0	0	84 418
1.2 Nuclear Fuel Cycle and Materials Technologies	57 000	0	115 103	172 103	0	0	0	0	172 103
1.3 Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy	34 000	0	31 613	65 613	0	0	0	0	65 613
1.4 Nuclear Science	351 900	0	376 914	728 814	4 000	0	36 318	40 318	769 132
1. Major Programme 1	**469 900**	**0**	**581 048**	**1 050 948**	**4 000**	**0**	**36 318**	**40 318**	**1 091 267**
2.1 Food and Agriculture	2 115 449		529 280	2 644 730	126 000	0	0	86 000	2 770 730
2.2 Human Health	1 459 360		256 215	1 715 575	0	0	0	0	1 715 575
2.3 Water Resources	188 406		42 619	231 025	0	0	0	0	231 025
2.4 Environment	0		32 818	32 818	0	0	0	0	32 818
2.5 Radioisotope Production and Radiation Technology	391 500	6 240	296 018	693 758	0	0	0	0	693 758
2. Major Programme 2	**4 154 715**	**6 240**	**1 156 951**	**5 317 906**	**126 000**	**0**	**0**	**86 000**	**5 443 906**
3.2 Safety of Nuclear Installations	7 500	0	0	7 500	0	0	0	0	7 500
3.3 Radiation and Transport Safety	28 560	0	0	28 560	0	0	0	0	28 560
3.4 Management of Radioactive Waste	12 900	0	55 305	68 205	0	0	0	0	68 205
3.5 Nuclear Security	54 500	0	11 525	66 025	0	0	8 433	8 433	74 459
3. Major Programme 3	**103 460**	**0**	**66 830**	**170 290**	**0**	**0**	**8 433**	**8 433**	**178 724**
Total	**4 728 075**	**6 240**	**1 804 830**	**6 539 145**	**130 000**	**0**	**44 752**	**134 752**	**6 713 897**

Total Contract awards:	**4 858 075**
Total CRP purchases:	**6 240**
Total RCM expenditures:	**1 849 582**
Total CRA expenditures:	**6 713 897**



1.1 Nuclear Power	2.4 Environment
1.2 Nuclear Fuel Cycle & Materials Technology.	2.5 Radioisotope Production and Radiation Technology.
1.3 Capacity Building & Nuclear Knowledge Maintenance	3.2 Safety of Nuclear Installations
1.4 Nuclear Science	3.3 Radiation and Transport Safety
2.1 Food and Agriculture	3.4 Management of Radioactive Waste
2.2 Human Health	3.5 Nuclear Security
2.3 Water Resources	

Details of 2011total obligations by project and type of award are provided in Table 2 below, followed by the list of IAEA's 2011 Active Project Names for reference.

Table 2: Distribution of Total 2011 Funds Obligated by IAEA Projects

Programme /Project[1]	Research Contracts		Technical Contracts		Doctoral Contracts		CRP Purchases	Total €	RCM		Overall Total €
	No.	Amount €	No.	Amount €	No.	Amount €	Amount €		No.	Expenses	
1.1. Nuclear Power											
1000020	5	7 500						7 500	2	33 812	41 312
1000021	1	3 000						3 000			3 000
1000022	1	5 000						5 000			5 000
1000023	3	5 500						5 500	1	13 155	18 655
1000025	4	6 000						6 000	1	10 451	16 451
Sub Total	**14**	**27 000**	**0**	**0**	**0**	**0**	**0**	**27 000**	**4**	**57 418**	**84 418**
1.2 Nuclear Fuel Cycle and Materials Technologies											
1000031	0	0						0	1	7 273	7 273
1000034	3	16 000						16 000		32 051	48 051
1000037	2	12 000						12 000			12 000
1000039	6	24 000	1	5 000				29 000	2	75 779	104 779
Sub Total	**11**	**52 000**	**1**	**5 000**	**0**	**0**	**0**	**57 000**	**3**	**115 103**	**172 103**

[1] See full IAEA's 2011 Project Names on page 9

Programme /Project[1]	Research Contracts		Technical Contracts		Doctoral Contracts		CRP Purchases	Total €	RCM		Overall Total €
	No.	Amount €	No.	Amount €	No.	Amount €	Amount €		No.	Expenses	
1.3 Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy											
1000046	1	4 000						4 000	1	16 740	20 740
1000047	6	30 000						30 000			30 000
1000049	0							0	1	14 873	14 873
Sub Total	**7**	**34 000**	**0**	**0**	**0**	**0**	**0**	**34 000**	**2**	**31 613**	**65 613**
1.4 Nuclear Science											
1000061	5	21 000						21 000	1	18 822	39 822
1000062	1	5 000						5 000			5 000
1000063	5	21 000						21 000	3	64 906	85 906
1000064	9	38 000						38 000	1	18 400	56 400
1000065	3	14 000						14 000	1	24 910	38 910
1000067	9	31 500						31 500	1	42 209	73 709
1000068	1	4 000						4 000	1	25 514	29 514
1000069	1	4 000						4 000	1	36 318	40 318
1000072	7	28 000						28 000	2	46 535	74 535
1000073	5	20 000						20 000	2	28 247	48 247
1000075	14	56 300	1	4 000				60 300	2	48 275	108 575
1000077	25	109 100						109 100	2	59 096	168 196
Sub Total	**85**	**351 900**	**1**	**4 000**	**0**	**0**	**0**	**355 900**	**17**	**413 232**	**769 132**
2.1 Food and Agriculture											
2000005	22	160 592	9	80 000				240 592			240 592
2000006	15	120 000	1	10 000				130 000			130 000
2000007	31	269 486	5	52 500				321 986	2	43 993	365 979
2000008	10	93 551						93 551	1	26 075	119 626
2000009	8	56 500						56 500	2	64 185	120 685
2000011	11	92 400						92 400	1	45 310	137 710
2000012	18	114 800	1	10 000				124 800			124 800
2000014	23	190 321						173 521	2	90 579	280 900
2000016	23	178 100	1	7 500				185 600	2	61 567	247 167
2000017	22	164 000						164 000	3	78 458	242 458
2000020	23	136 000	4	34 500				170 500	2	34 785	205 285
2000021	19	125 000	4	32 000				157 000			157 000
2000022	15	162 200	6	84 000				246 200	1	28 571	274 771
2000023	8	47 000	2	14 000				61 000	2	55 756	116 756
Sub Total	**249**	**1 916 949**	**33**	**324 500**	**0**	**0**	**0**	**2 217 649**	**18**	**529 280**	**2 770 730**
2.2 Human Health											
2000026	28	276 660	3	10 500	5	72 800		359 960	1	21 761	381 721
2000027	12	108 000	1	10 000				118 000			118 000
2000028	12	122 500	2	20 000				142 500	2	34 081	176 581
2000032	6	46 000	1	8 000				54 000	2	43 360	97 360
2000033	13	126 000						126 000			126 000
2000034			1	34 500				34 500			34 500
2000036	7	42 000	1	5 000				47 000			47 000
2000039	19	67 500	2	17 000				84 500	2	33 206	117 706
2000040	45	220 900	3	28 000				248 900	3	69 901	318 801
2000041			2	16 400				16 400	1	18 322	34 722
2000042	20	99 000	1	8 500				107 500			107 500
2000045	6	30 000						30 000	1	17 588	47 588

Programme /Project[1]	Research Contracts		Technical Contracts		Doctoral Contracts		CRP Purchases	Total €	RCM		Overall Total €
	No.	Amount €	No.	Amount €	No.	Amount €	Amount €		No.	Expenses	
2000047	12	54 000	1	5 000				59 000	1	17 995	76 995
2000048	4	17 500	1	7 600	2	6 000		31 100			31 100
Sub Total	**184**	**1 210 060**	**19**	**170 500**	**7**	**78 800**	**0**	**1 459 360**	**13**	**256 215**	**1 715 575**
2.3 Water Resources											
2000057	2	28 000						28 000			28 000
2000059	7	44 250						44 250	2	42 619	86 869
2000060	9	40 856						40 856			45 356
2000061			1	30 000				30 000			30 000
2000064	8	40 800						40 800			40 800
Sub Total	**26**	**158 406**	**1**	**30 000**	**0**	**0**	**0**	**188 406**	**2**	**42 619**	**231 025**
2.4 Environment											
2000078								0	1	32 818	32 818
Sub Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**32 818**	**32 818**
2.5 Radioisotope Production and Radiation Technology											
2000090	11	56 000	1	5 000				61 000	1	26 830	87 830
2000091	17	77 500						77 500	1	39 626	117 126
2000092	11	55 000					6 240	61 240	2	62 043	123 283
2000094	10	40 000						40 000	1	70 240	110 240
2000095	24	103 000						103 000	2	63 143	166 143
2000096	11	55 000						55 000	1	34 136	89 136
Sub Total	**84**	**386 500**	**1**	**5 000**	**0**	**0**	**6 240**	**397 740**	**8**	**296 018**	**693 758**
3.2 Safety of Nuclear Installations											
3000030	3	7 500						7 500			7 500
Sub Total	**3**	**7 500**	**0**	**0**	**0**	**0**	**0**	**7 500**	**0**	**0**	**7 500**
3.3 Radiation and Transport Safety											
3000035			2	28 560				28 560			28 560
Sub Total	**0**	**0**	**2**	**28 560**	**0**	**0**	**0**	**28 560**	**0**	**0**	**28 560**
3.4 Management of Radioactive Waste											
3000055	0	0						0	1	29 271	29 271
3000056	0	0						0	1	15 099	15 099
3000059	3	12 900						12 900	1	10 936	23 836
Sub Total	**3**	**12 900**	**0**	**0**	**0**	**0**	**0**	**12 900**	**3**	**55 305**	**68 205**
3.5 Nuclear Security											
3000068	1	35 000						35 000	2	19 959	54 959
3091068	3	11 500	1	8 000				19 500			19 500
Sub Total	**4**	**46 500**	**1**	**8 000**	**0**	**0**	**0**	**54 500**	**2**	**19 959**	**74 459**
Total	**670**	**4 203715**	**59**	**575 560**	**7**	**78 800**	**6 240**	**4 864315**	**73**	**1 849 582**	**6 713897**

[1] See full IAEA's 2011 Project Names on page 9

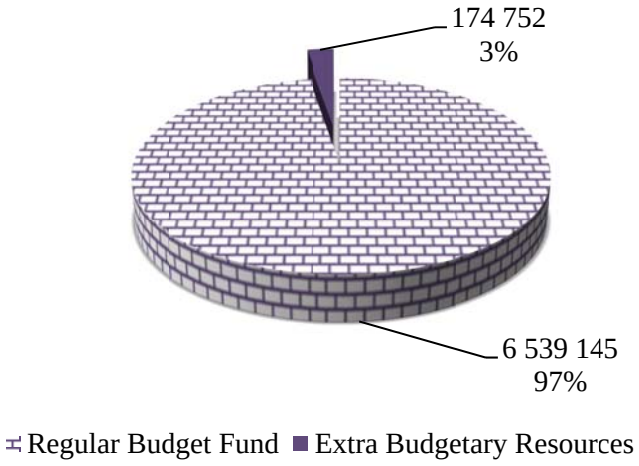
IAEA's 2011 Active Project Names Used in Table 2

Project Number	Project Name
1000020	Technology advances in water cooled reactors for improvements in economics and safety
1000021	Support for Fast Reactor Research, Technology Development and Deployment
1000022	Technology advances for gas cooled reactors (GCRs)
1000023	Common technologies and issues for small and medium sized reactors (SMRs)
1000025	Support for demonstration of nuclear seawater desalination
1000031	Supporting good practices in the uranium production cycle in particular for new countries
1000034	In-reactor behaviour and operational experience of fuel for nuclear power reactors
1000037	Providing technical guidance on good practices for long term management of spent fuel
1000039	Supporting emerging nuclear fuel cycle technologies for advanced and innovative reactors
1000046	Techno-economic analysis
1000047	Topical issues related to sustainable energy development
1000049	Implementing methodology and guidance for nuclear knowledge management
1000061	Nuclear data standards and evaluation methods
1000062	Nuclear data for radiotherapy using radioisotopes and external radiation sources
1000063	Atomic and molecular data for fusion experiments
1000064	Nuclear data for reactor dosimetry and analysis
1000065	Nuclear data for emerging issues and advanced nuclear facilities
1000067	Enhancement of utilization and applications of research reactors
1000068	Research reactor infrastructure, planning, and innovation
1000069	Addressing research reactor fuel cycle issues
1000072	Accelerator techniques for modification and analysis of materials for nuclear technologies
1000073	Fostering interdisciplinary developments in accelerator applications
1000074	Sustainable use of nuclear instrumentation for environmental and other applications
1000075	Nuclear spectrometry for analytical applications
1000077	Supporting plasma physics and fusion research
2000005	Soil management and conservation for sustainable agriculture and environment
2000006	Technologies and practices for sustainable use and management of water in agriculture
2000007	Crop Improvement for high yield and enhanced adaptability to climate change
2000008	Integrated and efficient mutation technologies for crop breeding and genetics
2000009	Integrated soil-water-plant approaches to enhance food production and biomass productivity
2000011	Integrated management of animal nutrition, reproduction and health
2000012	Reducing risk from transboundary animal diseases (TADs) and those of zoonotic importance
2000014	Innovative nuclear based approaches to maintain biodiversity and enhance livestock productivity.
2000016	Post-harvest phytosanitary applications of food irradiation to facilitate international trade
2000017	Traceability as an approach to control food contaminants and improve food safety
2000020	SIT to control exotic insect plant pests of agriculture and the environment
2000021	Area-wide suppression of native insect plant pests to reduce insecticide use and facilitate international trade
2000022	Strengthening capacities to use SIT in area-wide control of tsetse and screwworm populations
2000023	Development of the SIT for the control of disease transmitting mosquitoes
2000026	Maternal, Newborn and Child Nutrition
2000027	Overnutrition, Obesity and Non-Communicable Diseases
2000028	Nutrition and Infectious Diseases
2000032	Improvement of secondary prevention in ischemic heart disease through strengthening the use of nuclear cardiology

Project Number	Project Name
	techniques
2000033	Clinical PET/CT, molecular imaging and multimodality approach in diagnosis and control of disease
2000034	Quality Management in Professional Education and Clinical Practice
2000036	Molecular targeted radiopharmaceuticals for diagnosis and therapy in non-communicable diseases
2000039	Palliative cancer management using radiotherapy
2000040	Curative cancer management using radiotherapy
2000041	Advanced techniques for cancer radiotherapy
2000042	Applied Radiation Biology
2000045	Quality audits in dosimetry for radiation medicine
2000047	Quality assurance and guidelines for medical physics in the optimization of clinical radiation imaging
2000048	Quality assurance and medical physics developments in radiotherapy and therapeutic nuclear medicine
2000057	Synthesis and Dissemination of Global Isotope Data and Related Information
2000059	Assessment of Groundwater Resources at Local/National Scales
2000060	Development of isotope methodologies for water quality assessment and management
2000061	Isotope methods for the study of water and carbon cycle dynamics in the atmosphere and biosphere
2000064	Helium and Other Noble Gas Isotopes for Estimating Groundwater Recharge and Vulnerability to Pollution
2000078	Radioecological techniques for seafood safety
2000090	Supporting National Capacity Building for Production of Radioisotopes and Generators and Adoption of Emerging Products for Medical Applications
2000091	Supporting development, production and quality control of emerging diagnostic products
2000092	Cost effective radiopharmaceuticals: Development (complementary project to Project 2.2.2.4 of the Human Health programme)
2000094	Supporting National Capacity Building to Adopt Radiation Based Techniques for Industrial Process Management and Compositional Analysis of Materials/Objects
2000095	Radiation technology support for materials development and nanoscience
2000096	Supporting National Capacity Building to Adopt Radiation Processing techniques in Remediation of Pollutants
3000030	Enhancing safety of research reactors and knowledge sharing
3000035	Improving radiation safety standards
3000055	Pre-disposal management of radioactive waste
3000056	Managing disposal of radioactive waste and spent fuel
3000059	Supporting safe and cost effective decommissioning
3000068	3.5.2.2a Prevention Section: Research and development to support the further development of the nuclear security framework
3091068	3.5.2.2b D&R Section: Research and development to support the further development of the nuclear security framework

Extrabudgetary funds amounting to €174 752 were obligated in 2011 for financing contracts and RCMs. FIGURE 2 below illustrates the Proportion of Regular Budget and Extrabudgetary Funding in 2011.

Figure 2: Illustration of the Proportion of Regular Budget and Extrabudgetary Funding in 2011



The obligated extra budgetary funds were from the United States of America as shown in TABLE 3.

Table 3: Summary of Extra Budgetary Resources Obligated in 2011

Funds	CRP Code Title	Type of Expenditure and Amount in €				
		RCMs		Contracts		Total
		Number	Amount	Number	Amount	
United States of America (MO99)	**T12018** Developing Techniques for Small Scale Indigenous Molybdenum 99 Production Using Low Enriched Uranium (LEU) Fission or Neutron Activation	1	36 318	1	4 000	40 318
United States of America (PUI)	**D40043** Strengthening Capacities to Use SIT in Area-wide Control of Tsetse and Screwworm Populations	0	0	2	126 000	86 000
United States of America (NSF)	**J02002** Application of Nuclear Forensics in Illicit Trafficking of Nuclear and other Radioactive Materials	1	8 433	0	0	8 433
Total		**2**	**44 752**	**3**	**130 000**	**174 752**

3.2. Contracts and Agreements

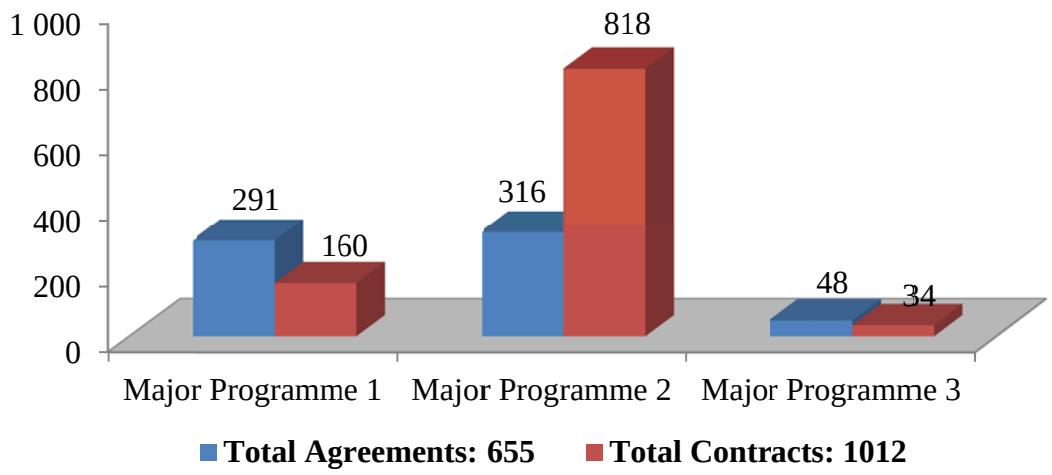
In 2011, funds were obligated for a total of 736 contracts signed with institutions in IAEA and FAO Member States (670 research contracts, 59 technical contracts, and 7 doctoral contracts). The

average contract size was €6600 per annum. In addition, 139 research agreements were awarded to institutions mostly located in developed countries.

At the end of 2011, there were 1667 active research, technical and doctoral contracts and research agreements supported by the IAEA. 94.8 % of these represented participation in the 130 active CRPs and 5.2% were individual contracts and agreements.

FIGURE 3 below shows the distribution of contracts and agreements by Major Programme.

Figure 3: Active contracts and Agreements by Major Programme at the end of 2011

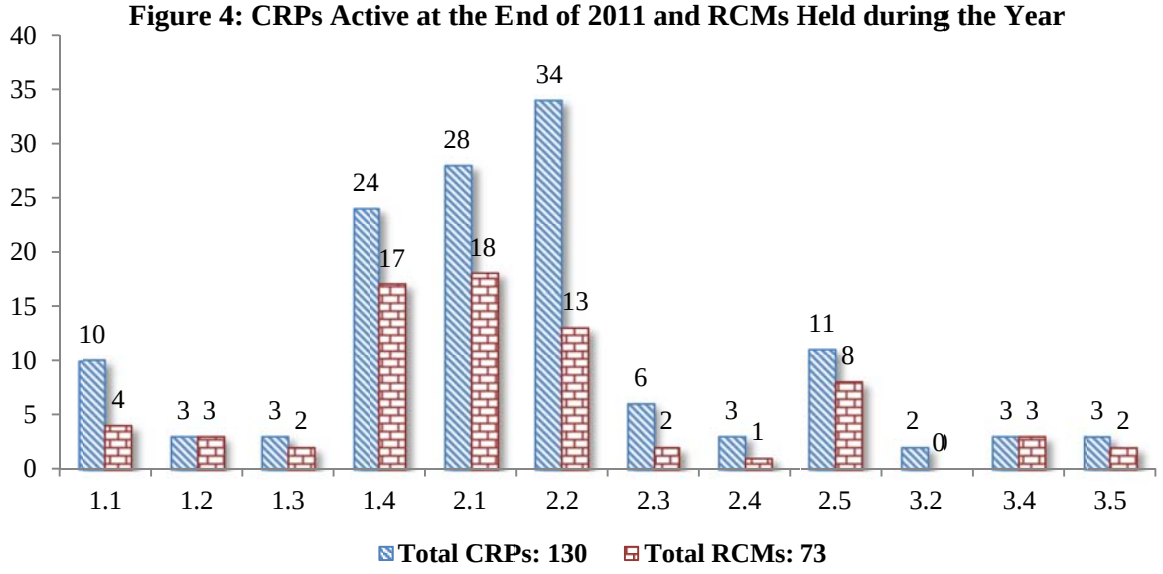


3.3. Research Coordination Meetings (RCMs)

73 Research Coordination Meetings (RCMs) were held in support of the CRPs (see *Supplement*, Chapter C.1 and C.II) and an amount of €1 849 582 was spent in support of these meetings.

FIGURE 4 shows the distribution of CRPs and RCMs held during the year, by programme.

Figure 4: CRPs Active at the End of 2011 and RCMs Held during the Year



1.1 Nuclear Power	2.3 Water Resources
1.2 Nuclear Fuel Cycle & Materials Technology.	2.4 Environment
1.3 Capacity Building & Nuclear Knowledge Maintenance	2.5 Radioisotope Production and Radiation Technology.
1.4 Nuclear Science	3.2 Safety of Nuclear Installations
2.1 Food and Agriculture	3.4 Management of Radioactive Waste
2.2 Human Health	3.5 Nuclear Security

3.4. Member State Participation

Institutes in 106 IAEA and FAO Member States participated in the CRA in 2011. 89% of the funds awarded for contracts were made to institutes in developing countries and countries in transition. FIGURE 5 shows the geographical distribution of all contract obligations in 2011. It is followed by Table 4 that shows the Distribution of Total 2011 Contract/Agreement Awards and Contract Obligations by Country and Programme in Euro. More detailed information per Major Programmes 1, 2 and 3 can be found in the *Supplement*, Chapter B.I.: 2011 Number of Contract/Agreement Awards and Total Contract Obligations per Country.

Figure 5: Geographical Distribution of Obligations for Research, Techncial, and Doctoral Contracts in 2011

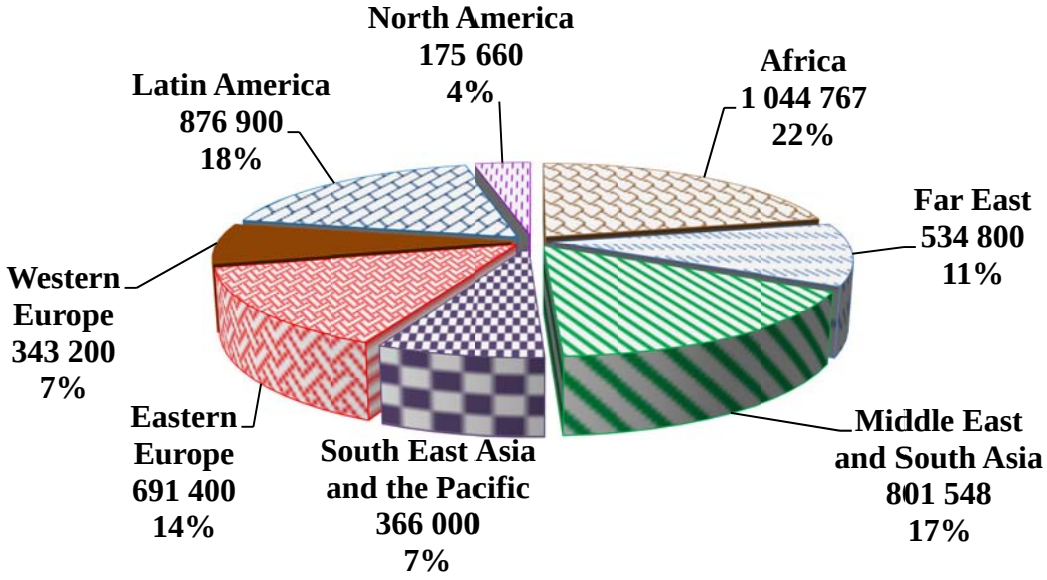


Table 4 shows the Distribution of Total 2011 Contract/Agreement Awards and Contract Obligations by Country and Programme in Euro. More detailed information per Major Programmes 1, 2 and 3 can be found in the *Supplement*, Chapter B.I.: 2011 Number of Contract/Agreement Awards and Total Contract Obligations per Country in Euro.

Table 4 Number of Active Contracts and Agreements and Total Contract Obligations per Country in Euro

Country	Number of Contracts	Total by Country	Number of Agreements
Algeria	2	10 000	0
Argentina	31	162 700	1
Armenia	1	4 000	0
Australia	4	64 900	4
Austria	5	68 000	4
Bangladesh	12	96 300	0
Belarus	2	7 000	0
Belgium	3	24 000	6
Benin	1	8 000	0
Bosnia and Herzegovina	1	10 000	0
Botswana	2	17 000	0
Brazil	36	194 300	2
Bulgaria	6	35 200	1
Burkina Faso	7	55 600	0
Cambodia	1	15 000	0

Country	Number of Contracts	Total by Country	Number of Agreements
Cameroon	3	13 000	0
Canada	11	112 660	7
Chile	9	55 000	0
China	57	366 400	3
Colombia	7	39 800	1
Costa Rica	1	17 000	0
Côte d'Ivoire	1	8 000	0
Croatia	6	28 800	0
Cuba	14	81 100	1
Czech Republic	11	64 700	5
Democratic Republic of the Congo	2	16 400	0
Ecuador	1	7 000	0
Egypt	13	50 300	0
Eritrea	1	8 400	0
Estonia	5	22 700	0
Ethiopia	5	37 260	0
Finland	0	0	3
France	0	0	5
Georgia	2	7 500	0
Germany	1	12 000	10
Ghana	11	68 251	0
Greece	3	15 000	0
Guatemala	4	29 000	0
Hungary	10	58 300	4
India	49	307 800	4
Indonesia	10	57 900	0
Iran, Islamic Republic of	9	49 921	0
Iraq	1	5 000	0
Ireland	0	0	1
Israel	1	5 000	0
Italy	3	22 500	10
Jamaica	2	30 000	1
Japan	2	20 000	10
Kenya	12	91 000	1
Korea - Republic of	6	36 000	1
Lebanon	2	12 000	4
Lesotho	1	8 000	0
Lithuania	1	5 000	0
Madagascar	1	8 000	0
Malawi	1	10 000	0
Malaysia	16	83 500	0
Mali	1	4 000	0
Mauritius	3	25 000	0
Mexico	19	128 800	1
Mongolia	2	16 800	0
Morocco	13	77 056	0

Country	Number of Contracts	Total by Country	Number of Agreements
Mozambique	1	8 000	0
Myanmar	1	4 200	0
Namibia	1	8 400	0
Netherlands	0	0	4
New Zealand	1	10 000	2
Nigeria	5	36 400	0
Pakistan	27	168 135	0
Peru	11	87 200	0
Philippines	4	32 400	0
Poland	18	82 500	1
Portugal	3	17 000	2
Romania	9	47 000	0
Russian Federation	19	119 000	4
Rwanda	1	10 500	0
Saudi Arabia	4	18 000	2
Senegal	3	98 400	0
Serbia	3	13 000	0
Sierra Leone	1	7 900	0
Singapore	5	25 700	0
Slovakia	5	58 500	2
Slovenia	6	35 000	0
South Africa	21	139 800	1
Spain	2	14 000	4
Sri Lanka	7	55 800	0
Sudan	3	16 000	0
Sweden	2	12 000	2
Switzerland	2	20 000	1
Syria Arab Republic	16	79 592	0
Thailand	17	107 000	0
The former Yugoslav Rep. of Macedonia	4	25 000	0
Trinidad and Tobago	2	15 000	0
Tunisia	7	45 900	0
Turkey	18	111 200	0
Uganda	6	50 000	0
Ukraine	10	48 700	0
United Arab Emirates	2	8 000	0
United Kingdom	5	40 500	7
United Republic of Tanzania	5	31 900	0
United States of America	7	63 000	17
Uruguay	7	45 000	0
Uzbekistan	2	6 500	0
Vietnam	7	65 000	0
Yemen	1	8 400	0
Zambia	5	42 300	0
Zimbabwe	3	26 400	0
Total	**732**	**4 794 275**	**139**

3.5. Coordinated Research Projects Completed in 2011

15 CRPs were completed in 2011, 5 of which concerned topics in Nuclear Power, Nuclear Fuel Cycle and Materials Technologies, Capacity Building and Nuclear Knowledge Maintenance for Sustainable Development and Nuclear Science, and 9 in Nuclear Techniques for Development and Environmental Protection and 1 in Nuclear Safety and Security. A list of these CRPs is included in the *Supplement*, Chapter A.III.

3.6. Evaluation for Completed CRPs

Coordinated Research Projects must be fully evaluated within one year after their completion. 13 CRPs were evaluated in 2010 after their completion: 2 related to Nuclear Science, 8 related to Nuclear Techniques for Development and Environmental Protection and 3 in Nuclear Safety and Security. A list of these CRPS is included in the *Supplement*, Chapter A.IV. It is followed by details reports on the outputs, impact, and relevance of these completed CRPs.

Work supported under these CRPs resulted in the publishing of about 200 articles and reports, scientific papers, proceedings of scientific conferences and contribution to international conferences, as well as various scientific databases and websites.

4. EXAMPLES OF COORDINATED RESEARCH ACTIVITIES ACHIEVEMENTS IN 2011 BY THEMATIC SECTOR

FUSION and PLASMA PHYSICS

CRP F1.30.12: Integrated Approach to Dense Magnetized Plasma Applications in Nuclear Fusion Technology (2007-2011)

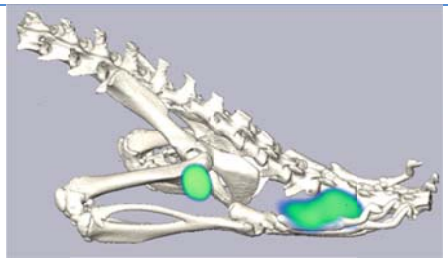
This project was designed in order to help strengthen the Agency's activities in support of science and technology for fusion power plants, and successfully achieved its aims of (i) utilizing modest plasma accelerators such as dense magnetized plasma devices to address pertinent issues in fusion material science and fusion technology for larger devices such as ITER; (ii) developing dense magnetized plasma technology; (iii) generating spin-off applications based on these devices; (iv) establishing a networking culture among the plasma accelerator community and creating connections with major fusion players; and (v) facilitating equipment sharing and expertise exchange. In addition, the project resulted in the development of a safe and low-cost technology to perform tritium-deuterium fusion discharges for the utilization of new activation detectors for neutrons, as well as powerful soft and hard pulsed X-ray sources for fusion applications. More information can be found by visiting http://www-naweb.iaea.org/napc/physics/PS/crp.htm

Beryllium "sandwich" Neutron Activation Detector for Pulsed Deuterium-Deuterium Fusion Sources

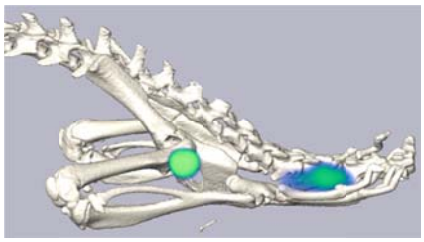
RADIOISOTOPES AND RADIOPHARMACEUTICALS

CRP F2.20.45: Development of Technetium-99m Radiopharmaceuticals for Sentinel Node Detection and Cancer Diagnosis (2007-2010)

Sentinel lymph node (SLND) detection involves finding a cancer free sentinel node in order to provide strong evidence that a tumor spread has not yet occurred. SLND has been increasingly used for the treatment of a variety of solid tumors, particular breast cancer and the melanoma. However, radiopharmaceuticals currently used for SLND have important shortcoming, including high retention at the injection site and limited uptake by sentinel nodes. New target-specific radiopharmaceuticals, such as radiolabelled mannosylated macromolecules, are considered to provide better uptake characteristics resulting in improved diagnostic sensitivity. The results obtained from pre-clinical biological studies in animal models clearly indicate that these new tracers are promising candidates for replacing the old generation of non-specific radiopharmaceuticals with more sensitive and selective SLND diagnostic agents. A book entitled "Technetium-99m Radiopharmaceuticals for Sentinel Lymph Node Detection" will be published in the last quarter of 2012 and will be available as IAEA Publication: http://www.iaea.org/Publications/index.html



1 hour post-injection



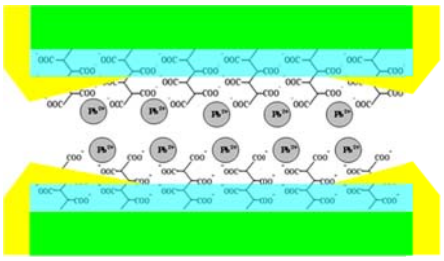
6 hours post-injection

Hybrid single-photon emission and X-ray computed tomographic (SPECT/CT) images of a rat model collected at different times with a high-resolution small-animal scanner showing the selective uptake (green) of the radiotracer in the first sentinel lymph node (left) and the activity remaining at the injection site (right). (Courtesy, Y. Arano, Chiba University, Japan)

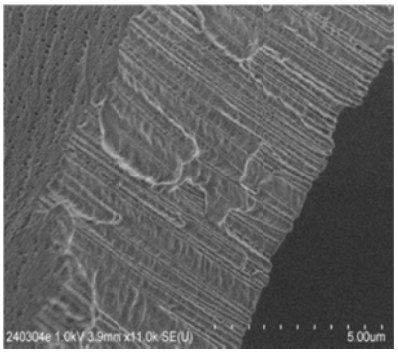
RADIOISOTOPES AND RADIOPHARMACEUTICALS

CRP F2.30.26 : "Development of Novel Adsorbents and Membranes by Radiation-induced Grafting for Selective Separation in Environmental and Industrial Applications" (2007-2010)

As emerging technologies continue to develop, new functional materials with specific characteristics are in higher demand in order to meet the demands of these new applications, for example bio-compatible material in "green" processes for separation and purification. This CRP was aimed at utilizing the potential of radiation technology to develop radiation grafted materials and assess their suitability for specific environmental and industrial applications. The project successfully achieved its objectives of developing a variety of modified membranes with specific characteristics, such as (i) sensing toxic heavy metal residue at nano molar concentrations after waste water treatment; (ii) application as a membrane in the fuel cell and battery separators with improved stability under actual test conditions; (iii) harvesting of valuable metal ions like gold, scandium and uranium at low concentrations from sources like spring water and sea water; and (iv) removal of anionic pollutants like chromate and phosphates and heavy metal ions from contaminated waste waters from industries. Based on the knowledge acquired during the CRP, materials were developed and successfully tested for removal of cesnium-137 from contaminated water samples after the Fukushima accident. Noticeable achievements of the CRP included filing of 5 patents, over 96 publications in high impact journals and international conferences, and human capacity building in Member States as the work done under the CRP formed the basis of 7 Ph.D. (4 awarded, 3 are under submission) and 7 Master degrees dissertations. More information on: http://www-naweb.iaea.org/iachem/working_materials.html



Scheme of a nanopore from a gold coated PAA functionalized radio-track etched ⍰-PVDF membrane (FME) after absorbing Pb2+ ions from polluted water



FESEM image of a track etched ⍰-PVDF membrane cross-section

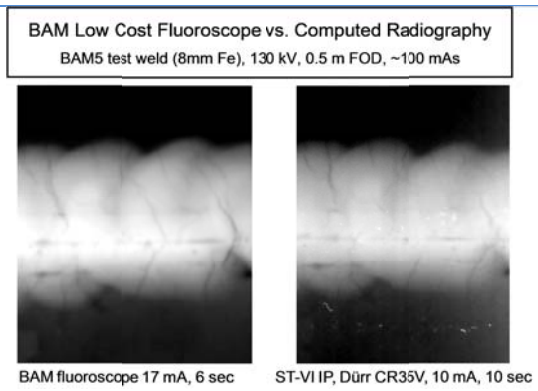
NON DESTRUCTIVE TESTING

CRP F2.20.43: Optimization of Digital Industrial Radiography (DIR) Techniques for Specific Applications and Development of Procedures and Protocols (2007-2010).

Non-destructive testing (NDT) methods, including radiography, are largely used for detection, location and sizing of surface and internal defects, for example in welds, castings, forging, composite materials and concrete. Radiographic testing (RT) consists of passing a beam of radiation (X rays or gamma rays) through a test specimen and detecting it on the opposite side. RT represents the largest NDT technique on the market and, at present, most RT is carried out using radiographic film as a detector. NDT laboratories in developed countries are rapidly progressing as NDT data becomes digitized. In addition, new imaging techniques using image intensifier systems, imaging plates, and flat panel detectors have increased the capacity for visualization of defects. Nevertheless, their cost remains

Example of the manufactered and partially assembled DFS

quite high. The purpose of this CRP was to develop an affordable digital fluoroscopic system (DFS) that could be introduced in developing Member States. The system developed was built locally by participating Member States, is about 5-10 times cheaper than a commercial DIR system and has a very similar image quality. It is not being used for national applications. More information in the document: 'Radiation Technology Report: Design, Development and Optimization of a Low Cost System for Digital Industrial Radiography'. http://www-naweb.iaea.org/na/resources-na/na-publications.html

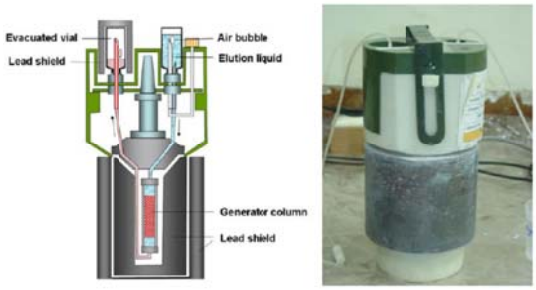


Example of results obtained on a welding sample from DFS (left) and commercial image plate system (right)

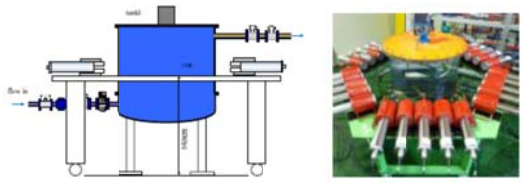
RADIOTRACERS INDUSTRIAL APPLICATIONS

CRP F2.20.44: Evaluation and Validation of Radioisotopes Generators Based Radiotracer for Industrial Applications (2007-2011).

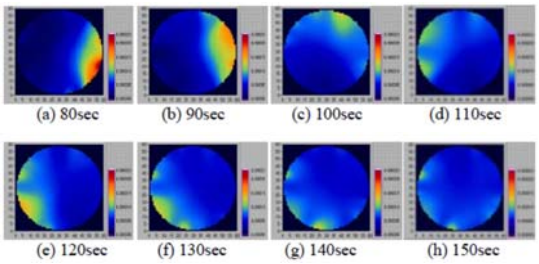
Radiotracers have been widely used to optimize industrial processes, improve product quality, save energy and reduce pollution. Their technical, economic and environmental benefits have been recognized both by the industrial and environmental sectors. The most important radiotracer techniques have been transferred to many developing Member States though IAEA Technical Cooperation projects. However, in spite of their benefits, radiotracer techniques continue to be underutilized. While there are a number of factors restricting the usage of radioisotope techniques, the primary one is the untimely availability of suitable radiotracers in developed and developing countries. The purpose of the CRP was to coordinate the development of industrial radionuclide generators and to validate generator-based radiotracers for use in harsh industrial conditions. An important outcome of this would be that the cost of radionuclide generators would be considerably lower, since the high costs of the facilities required to produce generators could be avoided. These objectives were reached, and 2 types of generators have been tested and validated, the Ge-Ga and Cs-Ba, both of which are appropriate for use in industrial and the environmental sectors. From a technical perspective, the cooperation between generator producers and users has been extremely valuable for both parties and these generators—and the associate protocols for tracer production—are now available. More information can be found in the document (still in progress): 'Radiation technology Series: Radiotracers Generators for Industrial Applications'. http://www-naweb.iaea.org/na/resources-na/na-publications.html



View and principle of a typical low-cost generator



Experimental setup for SPECT measurement



Examples of reconstructed images from injection of 68Ga 81.4 MBq

CRP G34001 (D4.20.11): Development of standardised mass rearing systems for male *Anopheles arabiensis* mosquitoes (2005-2011)

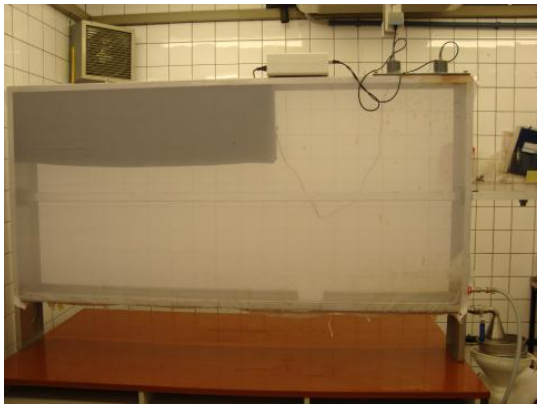
Mosquito-borne diseases threaten the lives and livelihoods of millions of people worldwide. Malaria alone affects over 500 million Africans and kills between one and three million people very year, most of which are children and pregnant mothers. With no vaccine or efficient drugs farmers must rely on vector control and insecticide use. Aside from being a serious health concern, these practices are not sufficient on their own to eliminate or drastically reduce vector populations and break the cycle of disease transmission.

The remarkable success of area-wide programmes integrating the SIT with other control tactics against screwworm, tsetse and fruit flies provides a sound basis for taking into account the use of the technology for suppression of mosquito vectors. The SIT relies on the sustained release of large numbers of mass-reared and sterilized males in the target area. Rearing methods to produce several million mosquitoes per week are currently lacking and this CRP was initiated to address these numerous gaps. During the CRP, elements of the SIT package for Anopheles arabiensis, one of the main malaria vectors in Africa, was developed and tested. It includes an affordable and competitive larval diet, a larval tray-rack holding system, a larvae-pupae separator, several types of adult mass-rearing cage and a blood feeding system. All this equipment was developed, refined and optimized during the five years of the CRP. Although the CRP contributed significantly to upscale mosquito production, the SIT for mosquito management is still at its infancy and many issues remain to be resolved and researched. The major bottleneck remains the separation of male from female mosquitoes (to allow male-only releases as the males are not vectors) and the availability of an adequate genetic sexing strain (GSS). This will be addressed in the next CRP to 'Explore mechanical, molecular, behavioral or genetic methods of sex separation in mosquitoes' (2013-2018).

Anopheles arabiensis female fed on human

The tray-rack system fully stacked with 50 thermoformed plastic trays in tilted position.

The larvae-pupae separator



The adult mass rearing cage prototype and the modified blood feeding system.

PLANT BREEDING

CRP D2.30.27: Molecular tools for quality improvement in vegetatively propagated crops including banana and cassava (2005-2010)

Cassava—which can produce more carbohydrates per hectare than any other major crops, can be cultivated on marginal soils and is drought tolerant—is one of the most important crops in sub-Saharan Africa. Despite its advantages, cassava suffers from a short shelf-life of its starchy storage roots upon harvest. This post-harvest physiological deterioration (PPD) renders the roots unacceptable as food or for processing within 24-72 hours of harvest. In traditional village societies, where cassava is harvested for food, PPD poses no real problem. However, with increasing urbanization in developing countries, as well as the use of the roots for processing into higher value products such as starch, the distance and time between field and consumer or processor is widening. The purpose of this CRP was to enhance the shelf life of the harvested cassava roots though mutation breeding in order to make them shippable to industrial facilities, thereby improving food security and pushing this subsistence crop into the realm of the 21st century cash crops. The potential gain of delayed PPD has been estimated at 460 million USD per year in Nigeria alone. More information at http://www-naweb.iaea.org/nafa/pbg/public/newsletters-pbg.html

Cassava sold in a traditional village market

Cassava's "shelf life" can be enhanced through mutation breeding from 24-72 hours to a few weeks.

ISOTOPE HYDROLOGY

CRP F3.30.15: Isotopic Age and Composition of Streamflow as Indicators of Groundwater Sustainability (2004-2010)

The discharge of groundwater to rivers and other surface water bodies plays an important role in maintaining the base flow that provides drinking water to millions of people around the world. This CRP has successfully achieved its aims of (i) improved interpretation of baseflow as indicator of shallow groundwater aquifers; (ii) characteristics of interactions between groundwaters and surface waters on the scale of large river basins; and (iii) investigation of quantitative parameters of shallow groundwater sustainability. The results provided new insights into the amount of groundwater that flows into rivers and the temporal dimension of the travel time of groundwater from the infiltration areas to its discharged streams in various geographical and geological settings. An analysis of river discharge records over at least five years showed an average of about 60-70% base flow, ranging between about 30% in basins with runoff dominated by wet seasons to 80% in karst systems dominated by subsurface flowpaths. In addition, stable water isotopes revealed that quick shallow groundwater contained waters up to two years old and tritium and chlorofluorocarbon provided information on the

The contribution of groundwater discharge to upper Danube basin was studied in this CRP

contribution of slower ground water components. The thorough collaboration by all participating teams allowed for the application and cross-comparison of identical isotopes and conventional techniques in all catchments. The CRP also made use of the recently established Global Network of Isotopes in Rivers (GNIR) and provided further valuable data to this database. More information on at http://www-naweb.iaea.org/napc/ih/documents/Newsletter/issue_26.pdf

NUTRITION

CRP E4.30.18: Zinc Nutrition in Early Life (2005-2011)

Poor zinc status is associated with growth retardation and increased morbidity, as well as mortality in low birth weight infants. The extent to which undernourished mothers maintain lactation capacity and zinc concentration in breast milk to adequately feed the infant and ensure zinc homeostasis of their small for gestational age babies is still largely unknown. This CRP successfully achieved its objective of contributing to a better understanding of zinc nutrition in early life by using cutting-edge stable isotope techniques to assess human milk intake, zinc absorption and metabolism for small for gestational age breastfed infants, as well as appropriate for gestational age breastfed infants. In addition, a study from Guatemala investigated zinc absorption in infants living in impoverished conditions, eliminating poor living conditions as an explanation for the commonly observed severe early growth failure in Guatemalan children. In this CRP, 50% of the contract holders were women, and two Ph.D.s and one Masters theses were completed (all by female candidates). The investigations undertaken in this CRP contributed knowledge on the impact of breast feeding on zinc nutrition and child health, and contributed to human capacity building in Member States. More information: http://www-naweb.iaea.org/NAHU/NAHRES/crp/e43018.html

Investigations on the impact of breast feeding on zinc nutrition and child health

Study with Moroccan women and babies on the role of zinc in infant nutrition

TRANSPORT SAFETY

J1.30.11: The Appropriate Level of Regulatory Control for the Safe Transport of Naturally-Occurring Radioactive Material (NORM)

The 1996 edition of the International Atomic Energy Agency (IAEA) 'Regulations for the Safe Transport of Radioactive Material' introduced radionuclide-specific exemption levels in lieu of the single 70 Bq/g value. The July 2003 International Conference on the Safety of Transport of Radioactive Material identified a need for additional research to relieve unnecessary regulatory burdens related to the transport of very-low-activity NORM. In response to this need, the IAEA undertook a CRP to identify the types of NORM materials transported and the resulting radiation doses to workers and the public as a result of transport. The general objective was to evaluate the effect and hazard of low-level radioactive materials and analyze the conditions under which these radioactive materials are transported. Additionally, the appropriateness of the existing regulations to the hazard of the transported materials was to be investigated. Nine Member States participated in the research project: Brazil, Canada, France, Germany, Iran, Israel, Romania, United Kingdom and the United States of America. A wide range of materials from NORM industries were reviewed, including those used for extraction of minerals (e.g., tantalum ores, zirconium ores, concentrates of such ores, etc.), direct-use materials (e.g., phosphate and potash), scales from oil and gas extraction industries, ores and waste material from uranium processing and other materials. Participating countries conducted surveys of industries involving transport of NORM and assessed doses to workers and members of the public through modeling and direct measurement. The research conducted during the CRP showed that the doses to personnel involved in transport operations (drivers and loaders) were within the range described in the regulatory context. Recommendations from the CRP have been included in the current 'Regulations for the Safe Transport of Radioactive Material: 2012 Edition SAFETY REQUIREMENTS No. SSR 6'.

The CRP identified the types of NORM materials transported and the resulting radiation doses to workers and the public as a result of transport.

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