



# ARCAL



REGIONAL CO-OPERATION AGREEMENT FOR THE PROMOTION  
OF NUCLEAR SCIENCE AND TECHNOLOGY IN LATIN AMERICA  
AND THE CARIBBEAN

**PHASE III  
(1995–1999)**

IAEA–September 2001



**ARCAL**

**REGIONAL CO-OPERATION AGREEMENT FOR THE PROMOTION OF NUCLEAR  
SCIENCE AND TECHNOLOGY IN LATIN AMERICA AND THE CARIBBEAN**

# **Phase III**

**1995-1999**

Document prepared by a  
Group of Experts and reviewed by the ARCAL National Coordinators

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## **Introduction**

### **ARCAL Programme**

The main objectives of the Regional Co-operative Agreement for the Promotion of Nuclear Science and Technology in Latin American and the Caribbean (ARCAL) Programme are (i) to promote the development of nuclear science and technology in Latin American and Caribbean countries and (ii) to promote technical co-operation between the countries in the region in the different fields of the peaceful use of nuclear energy, particularly in human health, nuclear safety and radiation protection, hydrology, agriculture, energy, industry, physical and chemistry sciences, nuclear information and maintenance of nuclear instruments.

At the time of publication of this report, September 2001, 20 countries participate in the ARCAL Programme. They are the following: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.

### **Previous Phases of ARCAL Programme - Phases I and II**

In 1984, ten countries agreed to participate in a Co-operating Regional Programme denominated by its Spanish acronym ARCAL (Arreglos Regionales Cooperativos para la Promoción de la Ciencia y la Tecnología Nucleares en América Latina y el Caribe), whose basic guidelines were approved at that time.

Since then, ARCAL has been assisting Latin American and the Caribbean countries in organising various activities that are designed either to promote or to apply technical co-operation among developing countries (TCDC) concepts within the Programme. Such activities, among others, cover: meetings, seminars, workshops, training and group activities, exchange of expertise, production of specific equipment for the needs of the region and radioisotopes as well as maintenance and repair of certain types of nuclear instruments and updating of nuclear medicine equipment.

Due to the fact that one of the main objectives of ARCAL is to facilitate and promote the transfer of technology in the nuclear field among all the participating countries in the Programme, all efforts during Phases I and II - from 1984 to 1994 - have been placed on the establishment of appropriate infrastructure, enabling them to make full use of nuclear techniques in their development programmes.

As has been shown in previous booklets related to Phases I and II, already published, the following achievements can be pointed out:

- Thousands of professionals and technicians from the region were trained in the different fields covered by the Programme;

- Support to the establishment in several countries of the region, of adequate legislation and regulations on radiation protection, and to the creation of regulatory bodies in some countries which lacked such structures. The support was achieved through the implementation of co-ordinated research programmes and intercomparison exercises, with the assistance of countries of the region.
- Establishment of laboratories for maintenance, repair and development of nuclear instrumentation and creation of three regional centres for maintenance and repair: one in multichannel analysers and digital electronics, another one on gamma camera and the third one on detectors and analogue equipment. These regional centres are providing services to all countries participating in ARCAL.
- A service to provide spare parts was established. This has helped to solve many problems where maintenance of nuclear instruments is required. Some countries are assisting many other countries outside of the ARCAL Programme in this area.
- Introduction and development of mutation breeding techniques in cereals, which contributed to obtain interesting mutants of rice, barley and wheat.
- Creation of a network of laboratories prepared for production of radioimmunoassay (RIA) kits for measuring thyroid related hormones, using bulk-reagents, with standard quality and suitable costs. Production of bulk reagents in the region required to prepare the kits of T-3 and T-4.
- The technology required to study neonatal hypothyroidism (which is a large problem in the region) was transferred to the countries of the region which did not have it before.
- Establishment or upgrading of the nuclear information infrastructure in ten countries of the region. The creation of a regional network of information exchange with several database systems allowed considerable increase of exchange of knowledge in the countries of the region, and have facilitated bilateral collaboration.

The specific goals and detailed achievements obtained during ARCAL Phases I and II were published in two booklets in September 1990 and June 2000, respectively.

### **ARCAL Phase III**

Phase III of ARCAL covers the period 1995 to 1999. The main objectives stated for this Phase were the following: (i) to enhance the economic and social impact of the project results, focusing on the solution of basic problems common to the countries in the region, rather than research or infrastructure building; (ii) to adopt new management principles to enhance the self sufficiency and ownership of the ARCAL Programme; and (iii) to conclude the process of the ARCAL Programme reorganisation and strengthening.

Among the measures taken to reorganise and strengthen the Programme, the following documents, among others, were prepared and used in implementing the Programme since their adoption:

- ARCAL Agreement;
- Manual of Procedures;
- Regional Co-operation Plan for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean;
- Goals and Objectives for the Fourth Phase of ARCAL; and
- Guidelines for the Formulation, Design, Implementation, Evaluation and Approval of ARCAL Projects.

With the purpose of increasing economical and social impact of ARCAL projects, several requirements were imposed on the projects to be implemented during this phase, such as: (i) to have clear and precise objectives; (ii) to present measurable results; (iii) to be designed to solve specific problems affecting the countries or a group of countries in the region; (iv) to be backed by a detailed Plan of Activity and adequate budget; (v) to reflect the real needs, interests and priorities of the countries of the region; (vi) to be prepared on the basis of the Regional Co-operation Plan; and (vii) to be submitted under the Guidelines for the Formulation, Design, Implementation, Evaluation and Approval of ARCAL Projects.

During the 1995-1999 period, the following ARCAL projects were implemented:

**Table I**  
**Projects implemented during Phase III**

<b>Sector</b>	<b>Project Title</b>	<b>Code</b>	<b>Implementation Period</b>
Radiological Protection	Radiation Protection Legal Framework	ARCAL XVII RLA/9/016	1993-1998
	Guidelines on Control of Radiation Sources	ARCAL XX RLA/9/028	1997 cont. after 1999
	Quality Assurance of Radiation Protection Service Laboratories	ARCAL XLI RLA/9/032	1999-cont.after 1999
Analytical Techniques	Quality Assurance in Analytical Laboratories	ARCAL XXVI RLA/4/013	1997-cont.after 1999
Nuclear Instrumentation	Nuclear Instrumentation Maintenance	ARCAL XIX RLA/4/011	1995-1999
	Training and Repair of Nuclear Instrumentation	ARCAL XXXV RLA/4/015	1999 -cont.after 1999
	Calibration of Radiotherapy Dosimetric Instrumentation	ARCAL XXXIV RLA/4/014	1999-cont.after 1999
Radioisotopes Production	Production and Control of Radiopharmaceuticals	ARCAL XV RLA/2/007	1991-cont. After 1999
	Harmonization of Standards for QA on Radiopharmacy	ARCAL XXXVIII RLA/6/038	1999-cont. after 1999
Industrial Applications	Industrial Applications of Nuclear Technology	ARCAL XVI RLA/8/016	1991-1998
	Industrial Applications of Tracer Technology & NCs	ARCAL XLIII RLA/8/024	1999-cont.after 1999
Plant Nutrition	Plant Nutrition and Soil-Water Management	ARCAL XXII RLA/5/036	1995-cont.after 1999
Food Irradiation	Development of Commercial Food Irradiation	ARCAL XXIX RLA/5/040	1997-1998
	Harmonized Quarantine Regulations for Fruit Irradiation	ARCAL XXXIII RLA/5/043	1999-cont.after 1999
Human Health	Upgrading of Nuclear Medicine Practices	ARCAL XXIII RLA/6/027	1995-cont.after 1999
	Improvement of Quality of Radiotherapy Practice	ARCAL XXIV RLA/6/029	1995-cont.after 1999
	Improved Quality Assurance in Clinical Dosimetry for Radiation Therapy	ARCAL XXX RLA/6/032	1997-cont.after 1999
	QC & Optimization of SPECT Clinical Protocols	ARCAL XXXII RLA/6/036	1999-cont.after 1999
	Standardization of Nuclear Nephrology Techniques	ARCAL XXXVI RLA/6/037	1999-cont.after 1999
	Screening and Diagnosis of Hepatitis C	ARCAL XL RLA/6/039	1999-cont.after 1999
	Quality Assurance in Mammography Studies	ARCAL XLVII RLA/6/040	1999-cont.after 1999 (cancelled 2000)
	International Basic Safety Standards in Medical Practices	ARCAL XLIX RLA/9/035	1999-cont.after 1999)
	Strengthening the Master of Medical Physics Degree	ARCAL L RLA/6/041	1999-cont.after 1999)
Medical Treatment in Radiological Accidents	ARCAL XXXVII RLA/9/031	1999-cont.after 1999	

Sector	Project Title	Code	Implementation Period
Hydrology	Aquifer Characterization for Sustainable Management	ARCAL XXXI RLA/8/023	1997-cont.after 1999
Reactor Safety Environment	Safety of Research Reactors	ARCAL XLIV RLA/9/033	1999-cont.after 1999
	Determining Content of Atmospheric Contamination	ARCAL XXXIX RLA/7/007	1999-cont.after 1999
Nuclear Information	Regional Information Network in the Nuclear Field	ARCAL XLII RLA/0/017	1999-cont.after 1999
	Regional Centre for IAEA Nuclear Data Services	ARCAL XLVI RLA/0/019	1999-cont.after 1999

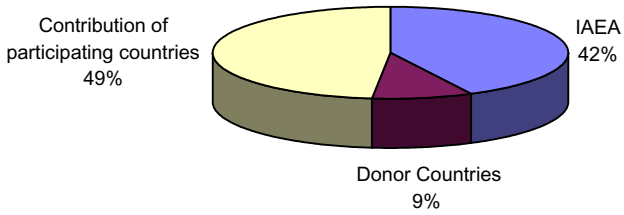
Table II shows the funds provided to the ARCAL Programme during Phase I, II and III indicating the main sources in U.S. dollars.

Table II  
**ARCAL Programme resources during Phases I, II and III.**  
(in US Dollars)

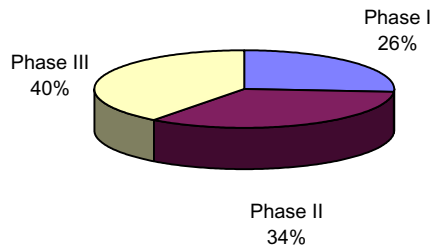
Year	IAEA	Donor Countries	Contribution of participating countries	Total
		<b>Phase I</b>		
1984	--	--	--	--
1985	916.744	42.750	478.080	1.437.574
1986	906.257	199.186	783.053	1.888.496
1987	1.075.396	539.061	1.146.691	2.761.148
1988	1.310.473	432.197	1.427.872	3.170.542
1989	1.221.385	543.053	1.398.956	3.163.394
<b>Subtotal</b>	<b>5.430.255</b>	<b>1.756.247</b>	<b>5.234.652</b>	<b>12.421.154</b>
		<b>Phase II</b>		
1990	1.503.643	572.335	1.365.223	3.441.201
1991	1.347.402	809.773	1.254.837	3.412.012
1992	1.547.317	273.513	1.585.620	3.406.450
1993	1.189.989	296.833	1.637.212	3.124.034
1994	1.389.594	146.411	1.382.845	2.918.850
<b>Subtotal</b>	<b>6.977.945</b>	<b>2.098.865</b>	<b>7.226.737</b>	<b>16.302.547</b>
		<b>Phase III*</b>		
1995	1.033.685	183.535	727.208	1.944.428
1996	1.285.276	154.211	848.189	2.287.676
1997	1.506.759	80.150	1.753.851	3.340.760
1998	1.575.002	55.590	2.606.448	4.237.040
1999	2.424.443	170.162	4.633.601	7.228.206
<b>Subtotal</b>	<b>7.825.165</b>	<b>643.648</b>	<b>10.569.297</b>	<b>19.038.110</b>
<b>Total</b>	<b>20.233.365</b>	<b>4.498.760</b>	<b>23.030.686</b>	<b>47.761.811</b>

\*Data as presented on the Tables " Summary of contribution to ARCAL Projects" from the preliminary reports of the Secretariat on the activities implemented during the respective years.

**Contribution of funds allocated to Phase I, II, and III  
(by source of funding)**



**Total funds allocated to each phase of ARCAL**



Following are the main achievements obtained in the implementation of ARCAL projects in Phase III.

## **Radiation Protection**

One of the main concerns of the countries is nuclear safety and radiation protection. Due to different degrees of development in ARCAL Member States in the third phase, activities were oriented towards the elaboration of regulatory guidance for the control of radiation sources. The main aim was to promote an effective control of the radioactive sources used in medical, industrial and research applications, harmonising and updating the existing procedures within the region to avoid unnecessary exposure and to limit the probability of accident occurrence, and adopting the International Radiation Safety Standards.

At the same time, it was necessary to identify laboratories that specialised in radiation protection services within the region to undertake an intercomparison programme.

Under the project ARCAL XX (RLA/9/028) “Guidelines on Control of Radiation Sources”, a set of regulatory guidances were prepared, approved and circulated to the participating countries with a view to put them provisionally into practice. Each one of these documents includes the main radiation safety requirements, as well a guidance for authorisation application and an inspector’s procedure. These guidances were also submitted to the Agency for possible issuance as an IAEA Technical Document (TECDOC). The following regulatory guidances were prepared and adopted:

- Radiotherapy;
- Nuclear Medicine;
- Industrial Radiography;
- Well Logging;
- Medical Radiodiagnostic;
- Industrial Gamma Irradiators; and
- Unsealed Radioactive Sources Used in Industrial Applications (Hydrology and Radiotracers).

It is important to emphasize that the regulatory guidances on Radiotherapy and Nuclear Medicine were discussed and harmonised with experts from the other regional agreements (AFRA and RCA), with the purpose to have consistent international regulatory safety guides to be used by IAEA Member States.

Several other common documents were also elaborated and circulated among the countries participating in the project as well as to other countries in the region. These included:

- Inspector’s Manual;
- Evaluation of the Radioactive Sources Control System Through Performance Indicators; and
- Guidance for Practical Identification of Radiation Sources and its Related Equipment - Used in Latin America and the Caribbean.

The following countries participated in the implementation of this project: Argentina, Brazil, Colombia, Cuba, Ecuador, Mexico, Peru, Uruguay and Venezuela.

Under the project ARCAL XLI (RLA/9/032) “Quality Assurance of Radiation Protection Service Laboratories”, a guidance was prepared for the Implementation of the General Requirements for Qualification of Test and Calibration Laboratories and guidance for the Implementation of a Quality Assurance Programme in Laboratories which provide Radiation Protection Services. The last one will allow the homogeneous evaluation of the general requirements for the implementation of a quality system based on the application of the ISO/IEC Guide 25 (“General Requirements for Qualification of Test and Calibration Laboratories”).

Since 2000, the selected laboratories of the region have started implementing the quality programme and an intercomparison programme.

Considering that the dissemination of information related to radiation protection in the region was so important, an ARCAL XX *Bulletin* has been published periodically and a web site was created to show the main achievements, news and general information associated with the field. The web site originally titled **www.arcalxx.org.pe** has recently adopted the title **www.radioproteccion.org.pe** to allow the possibility to disseminate all types of information on radiation protection of interest in the region and not only information on ARCAL XX.

## Nuclear Instrumentation

During the Third Phase of the ARCAL Programme, ARCAL XIX (RLA/4/011) “Nuclear Instrumentation Maintenance”, a continuation of ARCAL II was implemented from January 1995 to December 1997.

A total of 17 countries participated in this project: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.

The main objectives of the project can be summarised as:

- to improve the spare parts service;
- to strengthen the activities of the three Regional Training Centres;
- to establish/strengthen a laboratory in each participating country to repair and maintain the nuclear instruments;
- to emphasize the repair and maintenance of industrial and medical nuclear instruments;
- to promote specialised training on repair and maintenance of specific nuclear instruments;
- to extend the database on service manuals for nuclear instrumentation; and
- to design and manufacture small quantities of nuclear equipment for the participating countries.

The project performed several activities as shown in the table below.

Table III  
**ACTIVITIES PERFORMED UNDER ARCAL XIX (RLA/4/011)**

ACTIVITIES	QUANTITY
Courses held in Regional Training Centres	14
Regional Workshops	7
Regional Seminars	1
Establishment of National Laboratories	3**
National Training Courses	6
Co-ordination Meetings	2
Spare Parts Service	318
Database Updating	3***

\*\*Three national laboratories in three different countries were established.

\*\*\*Considering one per year.

In addition to these programmed activities, another 27 activities not initially programmed, were achieved (mainly national training courses).

The following results were achieved by the project:

- A total of 318 spare parts were supplied to several countries with a total cost of US\$51,550. This provision made possible the repair by the national laboratories and the Regional Centres of 240 diverse pieces of equipment, and eight gamma cameras, worth a total value of US\$1,753,350. For the repair of the equipment and instrumentation a total of US\$296,041 was invested, which works out at a gain of US\$5.90 for each dollar invested.
- The Regional Training Centres of Brazil (multichannel analyzers and digital electronics) and Mexico (nuclear detectors and analog electronics) were set up to perform activities of training and equipment repair as well. The table below presents the activities performed by each Regional Centre:

Table IV  
**ACTIVITIES PERFORMED UNDER EACH REGIONAL CENTRE  
 PARTICIPATING IN  
 ARCAL XIX (RLA/4/011)**

	<b>BRAZIL</b>	<b>MEXICO</b>	<b>COLOMBIA</b>	<b>TOTAL</b>
			†	
<b>Training Courses</b>	5	6	3	14
<b>Trained Personnel</b>	10	12	7	29
<b>Equipment Repaired</b>	9	43	-	52
<b>Value of Repairs (US\$)</b>	2,700	15,200	-	17,900
<b>Value of Repaired Equipment (US\$)</b>	36,000	440,500	-	476,500

†This Regional Centre was transferred to Venezuela.

Up to the year 1996, four countries of the region had not established a national laboratory for the repair and maintenance of nuclear instrumentation. These countries were: Costa Rica, Nicaragua, Panama and Dominican Republic. By the end of the project, in 1997, Costa Rica, Panama and Nicaragua had their national laboratories established and in operation.

A Technical Document (TECDOC) on the maintenance and repair of industrial nuclear equipment was issued, as well as another document containing the programme for national training courses on the repair and maintenance of nuclear instrumentation.

A total of 259 persons of the region were trained on the repair and maintenance of nuclear instrumentation (medical, industrial, radiation protection, research reactors, research, etc.) through regional workshops, national courses and the Regional Centres. It is worth noting that most of these training activities were performed using the infrastructure and experts from the region.

These achievements strengthened substantially the general conditions of the countries to repair and maintain the nuclear instrumentation, and as a consequence their ability to provide good operating conditions for the several laboratories of nuclear activities within the region.

Nevertheless, the service manuals database needs to be modified, taking into account the Internet, mainly. This modernisation must be one of the objectives of the follow-up project to be implemented during the fourth phase of ARCAL.

Concerning the design and production of equipment specific for the region, a regional workshop was carried out to evaluate radioimmunoassay equipment produced in Brazil, Cuba, Mexico. A technical report was issued presenting the performance of each prototype.

The total cost of the project was US\$903,396. From this total, 38% ( US\$345,016 ) was IAEA contribution, while the other 62% (US\$558,380 ) were contributions from the participating countries.

It is important to emphasise that through the strength achieved by the Regional Centres of Brazil and Mexico, the establishment and consolidation of the national laboratories in all countries and the expertise created should very likely lead in the near future to a self-sustainable condition in the field of repair and maintenance of nuclear instrumentation in Latin America and the Caribbean.

Two new projects related to nuclear instrumentation began in 1999, ARCAL XXXIV (RLA/4/014) "Calibration of Radiotherapy Dosimetric Instrumentation" and ARCAL XXXV (RLA/4/015) "Training and Repair of Nuclear Instrumentation".

Under the ARCAL XXXV (RLA/4/015), the following activities/goals were achieved in 1999:

- Six regional training events qualifying a total of 18 professionals on maintenance and repair of multichannel analysers, MCA and digital electronics, detectors and gamma cameras.
- A total of 143 professionals were trained in national training courses on the maintenance and repair of nuclear and medical general instruments.
- Establishment of three new Regional Centres: RIA, x-ray and nuclear medicine in Peru, development of software in Cuba, and gamma cameras in Venezuela.
- Enlargement of maintenance and repair possibilities of national laboratories in four countries (Ecuador, El Salvador, Nicaragua and Panama) and of two regional centres in Mexico and Brazil.
- Establishment of the national laboratory in the Dominican Republic. The completion of this laboratory brought the majority of the countries in the region to the level of having the minimum conditions for repairing and maintaining certain types of equipment, mainly in the medical area.

The table below shows the spare parts component supplied by IAEA, in the framework of the above mentioned projects during 1999.

Table V  
**SPARE PARTS COMPONENTS SUPPLIED BY IAEA UNDER ARCAL XXXV  
 (RLA/4/015)**

Work done	Numbers/costs
Spare Part Requests	63
Requests Accepted by IAEA	52
Pieces Delivered	224
Total Cost (US\$)	\$19,752

Under ARCAL XXXIV (RLA/4/014) “ Calibration of Radiotherapy Dosimetric Instrumentation”, the following activities/goals were achieved:

- Two regional training events which qualified 17 people on the electrical calibration of electrometers and ionisation cameras.
- Design and construction of the prototypes of one current source (ARCAL 01) and one reference source to check the calibration of electrometers (ARCAL 02). The construction of the remaining sources - one for each participating country - was postponed to be accomplished during the fourth phase of ARCAL.
- Establishment of a database of equipment failure and recommended solutions.
- Establishment of three Regional Centres - in Brazil, Cuba and Mexico - for repairing of dosimetric equipment used in radiotherapy.
- Elaboration of a manual with procedures for checking the electronic calibration of electrometers.
- Establishment of the basis for an intercomparison programme.
- Publication of the document “Calibration of Dosimetric Instrumentation Used in Radiotherapy”, describing the procedures for calibrating sources ARCAL 01 and 02.

## **Nuclear Analytical Techniques**

Most of the laboratories of the region do not have recognition or accreditation to satisfy the quality demands of the consumer markets in the national and international environment. To be able to satisfy these markets, the laboratories need to offer analytical services which demonstrate dependability of results given to internal and external users.

The first actions taken during the execution of the project ARCAL IV (RLA/2/003) “Nuclear Analytical Techniques” were designed to take the first steps to set up a Quality Managerial System to assure their capacity and technical competence.

One of the high-priority aspects in the execution of the Plan of Activities of ARCAL IV was to insure the quality of the analytical results produced by the participating laboratories. The need for the development of a programme to implement Systems of Quality Assurance in a group of analytical laboratories of the region was clearly identified.

In parallel, a group of training activities was carried out to provide the basic knowledge and tools to begin the introduction of quality concepts in the analytical laboratories of the region.

The execution of a project to support this activity was considered essential to assist a group of Latin American and Caribbean countries interested in the topic that had analytical laboratories, under conditions or with possibilities of receiving national or international accreditation.

The project ARCAL XXVI (RLA/4/013) “Quality Assurance in Analytical Laboratories” was designed during Phase III to apply a Quality System based on the guide ISO-25:1990 and to obtain from national or international organisations the recognition of the laboratories that use nuclear and complementary techniques.

To attend to national needs, the project outlined the following objectives:

- to design a programme of Quality Assurance in the analytical laboratories of the countries participating in the project;
- to set a System of Quality Assurance in these laboratories;
- to achieve recognition or accreditation, in the national or international environment, of at least one laboratory in each participating country; and
- to have an appropriate computer infrastructure to be able to prepare and process the information required for the implementation of the project, and for the establishment of a communication network among the countries.

The following results are expected at the end of the project:

- recognition or accreditation of at least one analytical laboratory in each of the countries participating in the project and
- preparation of a Manual of Quality Assurance and all the other relevant documentation for each of the participating laboratories.

The countries participating in the project since 1997 are Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, Ecuador, Mexico, Peru, Dominican Republic, Uruguay and Venezuela. At the beginning of the project, a diagnosis based on surveys was carried out with 78 laboratories which were providing analytical services to know their interest and their situation with regard to the implementation of a Quality Assurance System (Level of Progress).

The criteria for selection of the laboratories was determined based on the data collected. Priority was given to laboratories tied to nuclear institutions, applying nuclear and complementary analytical techniques such as analysis by neutron activation, x-rays fluorescence, nuclear spectroscopy, atomic absorption, and with the highest level of progress. In the first instance, 50 laboratories were selected to participate in the implementation of the project.

The laboratories prepared their own respective Manuals of Quality, and these were presented by the Project Co-ordinators during their second meeting carried out in Santo Domingo, Dominican Republic, in November 1998. The evaluation of the 50 laboratories selected to participate in the implementation of the project was done during 1999.

The following main activities were executed within this project.

- Two regional training events:
  - ◊ Training of Quality Auditors in the analytical laboratories. A total of 16 people and an IAEA expert participated in this event.
  - ◊ Metrology and calibration in analytical techniques. A total of 24 people and two IAEA experts participated.
- Five national training events to prepare internal auditors, in which more than 50 people participated as per reported by two of the participating countries.
  - ◊ Determination of the technical procedures for the accreditation and/or to obtain a national or regional recognition given by the participating laboratories.
  - ◊ Two experts meetings for matching software possibilities with the requirements for Quality Control of the analytical information and for the revision of the Aptitude Test Plan prepared by Chile in implementation of this project. In these meetings the program WINAMIDAS was co-ordinated with the program BAXCER.
  - ◊ Thirteen missions of IAEA experts were implemented to assist participating laboratories to prepare the corresponding technical documentation and to carry out national events to train internal auditors

- ◇ Preparation of the Manual on Quality for the participating laboratories. As a result, there has been a substantial improvement on the quality of the services carried out by these laboratories.

Due to the implementation of this project in Chile, their neutron activation analysis laboratory has already received accreditation from the competent national authorities. This represents a success in the execution of the project for this country and fulfils one of the project's main objectives.

Internal audits were carried out in the participating laboratories that participate, with the purpose of determining the level of development and progress in each laboratory.

## **Production and Control of Radiopharmaceuticals**

Phase III offered the opportunity to continue actions which had been initiated in Phase II to meet established objectives, with emphasis on the following:

- To prepare protocols for therapeutic radiopharmaceuticals based on Samarium-153 and other radionuclides which offer convenient physical characteristics for their use in palliative therapy of pain and to disseminate them and to train staff in their application.
- To develop radiopharmaceuticals based on technetium-99m, proteins, peptides, and monoclonal antibodies.
- To prepare a manual to compile recommendations for the Application of Good Practices for the Production of Radiopharmaceuticals.
- To establish a co-ordinated regional programme establishing the base for a university programme for radiopharmaceutical professionals.

The results reached during Phase III were the following:

- Improvement of the existing scientific level in the region, of basic and advanced knowledge in this field. The countries in the region have improved their processes to obtain and control bondings for modern radiopharmaceuticals, reagents sets, radiopharmaceuticals, blood cells and marked biomolecules.
- Thanks to the training and support in the supply of reagents in the region, strengthening of the local capacity for production and control of radiopharmaceuticals of first and second generation, of therapeutic agents to minimize pain (Sm-153-EDTMP) and of biomolecules such as Inmonoglobuline G to be used as a diagnostic agent in inflammatory/infection cases.
- Re-inforcement of achievements by generating and/or complementing the availability and use of equipment, infrastructure and human resources for training tasks, research and development and by co-ordinating activities of the project with other support programmes at the national and international levels.
- Preparation of a regional document oriented to co-ordinate radiopharmaceutical teaching programmes. This promoted and motivated the contacts with local university authorities at undergraduate and graduate levels in accordance with the guidelines given in this document.
- Writing of a harmonised proposal for the Registration and Sanitary Control of the Radiopharmaceuticals in Latin America, which has been put for consideration by the sanitary authorities of each country.
- Preparation, editing and dissemination of the Manual of Radiopharmaceutical Good Practices with the view to offer a guide to all radiopharmaceutical laboratories with emphasis in the laboratories of hospital radiopharmaceuticals. This document is also meant to be used as specific reference material for the elaboration and adoption of norms related to any activity in radiopharmacy which could be considered by the competent sanitary authorities in the region.

From the above, it can be concluded that the Phase III of ARCAL XV consolidated the achievements reached in Phase II and brought a direct benefit in the practice of radiopharmacy as it enhanced professionalism, allowed wider coverage and reduced costs. The great socio-

economic impact of this project is determined by the degree of development reached in this field contributing to national and regional independence. The main benefits obtained with the development of the project were the following:

- The professionals of radiopharmacy in response to the needs of nuclear medicine, have made available more radionuclides and modern radiopharmaceuticals using the resources of the region. This has a direct benefit in the health of the people in the region.
- The continuous generation of qualified human resources through the progressive establishment of study plans for the training at university level of radiopharmaceutical professionals according to the general regional guidelines given in the document Co-ordination of Radiopharmacy Teaching Programmes.
- The scientific support which has been made available to the authorities of specialists in Radiopharmacy. The harmonised proposal for the Sanitary Registration of Radiopharmaceuticals initiates a more regulated approach which had not existed in the countries of the region.
- The application of the Manual of Radiopharmaceutical Good Practices at all stages, especially in hospital radiopharmacy, guarantees the correct and applicable use of radiopharmaceuticals for diagnosis.
- Support to the government authorities, public and private institutions related to the application of radiopharmacy, promoting a better knowledge of the benefits from radiopharmacy and identifying needs in this field.

As a continuation of the process to improve the quality of radiopharmacy in the region, ARCAL XXXVIII (RLA/6/038) “Harmonisation of Standards for Quality Assurance in Radiopharmacy” began in 1999. The main objective of this project is to elaborate a technical document on a Harmonised Programme of Quality Assurance in Radiopharmacy, taking into consideration the three types of existing radiopharmacy: hospital, centralized and industrial, and to implement these standards in the countries of the region.

Two expert meetings were carried out in 1999 to prepare a technical document on the Harmonised Programme of Quality Assurance in Radiopharmacy. Following a revision, the document was circulated to all the countries of the region.

After the programme is implemented, all the countries participating will have quality assured radiopharmaceuticals. Also, it is expected that the procedures used in the hospital and centralized radiopharmacy will correspond to the guidelines set in the Harmonized Programme of Quality Assurance prepared within the framework of this project. Both results will translate to direct benefits for the patients.

## **Industrial Application of Nuclear Technology**

The activities of ARCAL XVI (RLA/8/016) “Industrial Applications of Nuclear Technology”, which begun in Phase II continued until this project was completed in 1998. Technical support activities were carried out through the provision of expert services, demonstrations, training, workshops and exchange of information in the areas of tracer, nucleonic control systems and radiation technology.

This project was key to the full recognition in the region of the virtues of the use of nuclear technology for the sterilisation of medical products. The project focused its activities in the introduction of international norms like Norm ISO 11.137 (the English version was translated into Spanish by Cuba and Chile) and the verification of the correct operation of irradiation facilities by means of dosimetric intercomparisons among several countries. These activities gave impetus to the construction of new commercial irradiation plants in Brazil.

The organisation of workshops and other dissemination activities in the area of the ionising radiation gave way to new research and developments, such as the case of the use of electron accelerators for the decontamination of gases in industrial chimneys in Chile and Brazil, development of new biomaterials in Argentina and Cuba, establishment of tissue banks in Mexico, Brazil and Chile. In addition, an important step was made in the use of radiation for curing paints and varnishes using UV, as well as in the establishment of new formulations in the cross-linking of plastics used in cable isolation in Brazil.

In the area of systems for nucleonic control, only minor achievements were obtained, due partly to limitations in the economy and international trade factors. Nevertheless, new equipment was designed such as the humidity-measuring devices based on neutron reflection developed and built in Cuba for the construction materials industry.

Important achievements were made in the use of tracers in studies of environmental impact and hydrology resources. It is necessary to point out that the donation of state-of-the-art portable equipment by the French Government was a key element to reach the objectives. In Chile, these instruments have expanded and optimized the use of tracers in the mining and metalurgical Industry.

The following are the achievements from this project:

- Establishment of regional and national training and technological centres in different selected areas.
- Possibility to integrate, through the work done, different national institutions and develop human resources and financial savings.
- Establishment of new research and development approaches in the areas of ionising radiation, tracer and of nucleonic control systems.
- Establishment of an important forum to exchange and to disseminate research and development results in the different areas, particularly through regional seminars.

The project ARCAL XLIII (RLA/8/024) “Industrial Applications of Tracer Technology and Nucleonic Control Systems” began in 1999. The objectives set for the project were the following:

- To systematize, by means of the elaboration of manuals, norms and procedures, the methodologies of tracer technology (TT) and nucleonic control systems technology. Particularly, to validate software and to prepare guides with norms and procedures for the techniques and applications in (a) tracers for the production and recovery of petroleum; (b) gamma and neutron well logging in the petroleum and petrochemical industry; (c) determination of residence times for diagnostics in the petroleum and petrochemical industry; (d) tracers for water treatment plants; and (e) design, construction of prototypes, calibration and operation of NCS.
- To adapt and adopt these technologies and to transfer them from the national laboratories or universities to the end users.
- To establish and to consolidate the Technology Transfer Centres for training staff in co-ordination with the end users of the related technologies.
- To prepare a quality assurance guide for products and related services using TT and NCS.

The following achievements were made under this project:

- A regional training workshop in the application of gamma and neutron well logging in the petroleum and petrochemical industry. A total of five people from four countries participated.
- Three national training events were organized in
  - ◊ gamma well logging technology for distillation columns in refineries, pipe and other similar systems
  - ◊ tracer technology in industry
  - ◊ tracer technology in water treatment plants
- Establishment of two technology transfer Regional Centres, one in Venezuela and the other one in Brazil.
- Preparation of the following documents:
  - ◊ Guide of Procedures for the Design, Prototype Construction, Calibration and Sure Operation of Nucleonic Control Systems
  - ◊ Programme of Quality Assurance Management for TT and NCS
  - ◊ Norms and Procedures for Tracer Technology

## **Food and Agriculture**

The great diversity and complexity of the agricultural production system in Latin America is determined by differences not only in the physical environment such as soil, climate, topography, latitude and altitude, but also in the cultural and socio-economic conditions of the countries in the region. This poses a great challenge in the formulation of recommendations for adequate management of natural resources (soil and water) and external inputs to enhance agricultural productivity.

Implementation of this project began towards the end of 1996 for a total duration of five years with the following immediate objectives:

- To develop strategies for an integrated and efficient use of chemical fertilisers and alternative nutrient sources in different cropping systems, and
- To establish improved water and soil management practices to maintain land productivity and control soil degradation, in particular soil erosion.

Although several countries of the region showed interest in participating, only eight countries met the conditions set to participate: Argentina, Brazil, Chile, Cuba, Guatemala, Mexico, Uruguay and Venezuela.

During the first meeting of Project Co-ordinators held in October 1996 in Irapuato, Mexico, the Plan of Activities of the first part of the project (1997-1998) was formulated. Furthermore, the main soil fertility and water management problems affecting agricultural productivity in the participating countries were critically analysed as well as the role nuclear techniques could play in supporting applied research to overcome these barriers.

As a result of the first meeting, activities were oriented to collect and disseminate information on technologies generated from past national IAEA technical co-operation projects on the topics of plant nutrition, soil and water management. In the participating countries, groups of scientists and technical staff with skills and expertise in the use of nuclear techniques were formed for the implementation and co-ordination of the activities of the project. A regional network of field trials preferably located in farmers' fields was established to test the most promising technologies for increasing agricultural productivity. Close links with farmers' associations and extension services were recommended. Nuclear and related techniques such as neutron moisture meters have been provided and used to monitor soil water status and water balance. Similarly, N-15 and P-32 labelled materials were supplied to enhance the efficiency of nitrogen and phosphorus uptake from chemical fertilisers and other sources to increase their agronomic efficiency while protecting the environment.

During the second meeting of Project Co-ordinators held in March 1998, in Santiago, Chile, the progress made in implementation since the first meeting was assessed and the Plan of Activities for the Second Phase of the project (1999-2000) was formulated. Particular

attention was given to proper implementation of the regional network of field trials in order to reach not only the objectives of the project but also to have the desired impact by transferring the results to the end users.

A newsletter of the project was issued and distributed to keep the participants abreast of the latest developments. By the end of 1999, the main outputs/achievements in the project were the following:

- Improvement of the scientific capabilities existing in the region through the conduct of training such as regional/national workshops, national training courses and individual training in specialised centres of the region and if necessary, elsewhere. Some 300 scientists from the region had been trained and in some countries this led to the progressive adoption of an integrated approach to soil, water and nutrient management in cropping systems.
- Strengthening of the isotope analytical capabilities of the laboratories of the region through regional workshops and linkage to the international quality assurance programmes implemented by IAEA in the field. A network of regional laboratories was established and consolidated. Significant progress in the introduction of quality assurance in N-15 analysis had been made in laboratories of the region with excellent results. Four of them had qualified as IAEA recognized regional resource centres. The same laboratories had already applied for recognition as ARCAL Designated Centres. It should be noted that all N-15 analysis and related training is being done within the region.
- Increased awareness of the potential of the nuclear techniques to support research to increase soil fertility and crop productivity as evidenced from the results obtained in the regional network of field trials in the participating countries. The implementation of this regional network of field trials allowed the linkage and adequate integration of the researchers between themselves and collaborative work with the participation of extension personnel and the farmers. It also identified new areas of study under national or regional projects.
- Region-wise, dissemination of the role of the nuclear techniques in the study of plant nutrition, soil and water management and establishment of regional collaborative links through the elaboration of Technical Manuals on the topics mentioned above and participation in regional and national scientific events. Two technical manuals (one on phosphorus fertilisers and other on nitrogen fertilisers management) and one book (translation from English) on biological nitrogen fixation of common bean in Latin America were published. Other technical manuals were being prepared.

The reports on the field trials indicated that significant achievements in the development of technological packages on nutrient and water management for increased agricultural productivity were made. Activities for the year 2000 were planned to focus on the implementation of appropriate mechanisms for dissemination and transfer of the results to end-users and beneficiaries with the assistance of an expert on agricultural extension.

## **Food Irradiation**

The countries of the region produce products for domestic consumption and for export. Although the countries have legislation that allows irradiation of some products, a barrier for the future development of a market of irradiated products and for the trade among the countries exists due to the disparity of the legislation and authorization for irradiation of specific products. This obstacle has been decisive for postponing the application of the of Food Irradiation Technology (FIT) in the region, especially in view of the importance of the products of animal as well as vegetable origin.

Keeping in mind these difficulties, ARCAL XXIX (RLA/5/040) “Development of Commercial Food Irradiation” set the following specific objectives:

- To generate and to establish a regional regulatory scheme which would define the handling of irradiated products based on the legislation in force and/or new ones as well as based on the “Codex Alimentarius General Standard”.
- To assist countries in the region in the development and dissemination of clear and pertinent information on food irradiation among objective groups interested in the subject.
- To assist the countries in the region to transfer food irradiation technology to the industry by selecting to handle specific products for a certain market.
- To assist the countries in conducting pilot tests to reach interregional markets.

With the implementation of this project the following results were achieved:

- Organization of nine national seminars to disseminate the food irradiation technology: three in the health sector, with the participation of 210 people and six for the commercial sector with a total of 335 participants.
- Use of the Model Regulation for Food Irradiation in Latin America and the Caribbean, adopted in the seminar carried out in Lima, Peru, in 1997. The Consultative Group on Food Irradiation fully supported the preparation and revision of the national regulations of Argentina, Brazil, Chile, Paraguay, Peru and Uruguay.
- Participation of several companies from Brazil, Argentina, Chile and Peru in tests exchanging transport of irradiated products (pears and apples between Argentina and Brazil, pepper among Chile and Argentina, coffee and pepper among Argentina and Chile, and cocoa between Peru and Chile).
- Establishment of working groups in the countries to elaborate and to adapt the national regulations on food irradiation as a result of the experience and results obtained with the implementation of the project.

- Preparation of diverse public information materials on food irradiation technology for dissemination in the health and commercial sectors in the participating countries.

ARCAL XXXIII, (RLA/5/043) “Harmonised Quarantine Regulations for Fruit Irradiation” set objectives to facilitate the commercialisation of fruits that have quarantine restrictions in the countries of the region.

- To elaborate a model of harmonised protocol to investigate the effectiveness of the quarantine treatment using irradiation that could be applied to each specific pest of interest for the regional and international trade.
- To elaborate a model Protocol for Control and Certification of the Quarantine Treatment using Irradiation.

Under the scope of this project, the following activities were executed:

- Revision of the radiation effects in the biology of the pests of economic importance for each country, as well as radiation effects in fresh fruits with quarantine restrictions.
- An expert mission to the countries participating in the implementation of the project, with the purpose of evaluating the potential treatment for irradiation of fresh fruits with quarantine restrictions, determining the selection of fresh fruits with commercial interest that could be treated by irradiation for quarantine purposes in each country based on the analyses carried out, and identifying the fundamental elements that should be included in the protocol to be prepared during the project.
- Compilation of the national legislation in force with the purpose of identifying those aspects that should be included in the protocol.
- Preparation of a protocol proposal for the Development of the Required Steps for the Employment of Irradiation as Quarantine Treatment, for evaluation by the competent authorities from the participating countries.
- Consideration of an acceptable common protocol would be elaborated for all the countries involved in the project during 2000.
- Elaboration of a protocol proposal for the Certification of Quarantine Treatment by Irradiation to be accepted by all the participating countries.

## **Human Health**

### **Gamma Camera Utilisation**

A project ARCAL XXIII, (RLA/6/027) intended to “Upgrade Nuclear Medicine practices” in the region was implemented during the period 1995-1998. The main aim of this project was to upgrade the gamma cameras existing in the region by using personal computers coupled with interfacing cards supported by adequate software programmes. By doing this, old gamma cameras could be updated and become very useful for modern clinical examination by the nuclear medicine professionals.

The following basic activities were carried out under this project:

- A regional training event on systems for upgrading gamma cameras. A total of 22 people participated.
- An expert meeting to select the most appropriate interfacing card and software for the successful conclusion of the project. Three interfacing card prototypes from Cuba, India and Slovenia were analysed. The Slovenian interface card was selected for upgrading the gamma cameras under the project along with the software submitted by Cuba.
- Supply of 38 interface cards for upgrading the same number of gamma cameras as well as 38 clinical software packages for the improved use of these cameras in the treatment of patients.
- Working group meeting of regional users of the portable imaging processing (PIP) system with the participation of 12 people from the same number of countries.
- Supply of 21 portable imaging processing (PIP) software systems to countries participating in the project.
- Expert services for the installation of the interface cards supplied under the project.

The project concluded in 1999 with the upgrading of more than 50 gamma cameras which represented a saving for the countries of between \$7 and 11 million, depending on the cost of acquisition of a new gamma camera in the international market.

The need to harmonise and optimise the clinic protocols related to single-photon emission computed tomography (SPECT) used in the region was identified. Therefore, in 1999, ARCAL XXXII, (RLA/6/036) “QC and Optimization of SPECT Clinical Protocols” was initiated with the following objectives:

- To design, construct and use a standard phantom for SPECT external quality control systems.
- To elaborate and implement a Quality Assurance Programme to the clinics in the region which have SPECT systems.

- To optimise SPECT clinic protocols used in medical studies.

As a result, the following activities/results were achieved:

- Training of 22 professionals from 11 countries in a regional training event related to Quality Assurance in SPECT systems.
- Design of a phantom adjusted to the needs of the project. It was determined that during the year 2000, a phantom would be given to each participating country.
- Two experts mission to elaborate the following protocols:
  - ◊ cardiac;
  - ◊ brain; and
  - ◊ other organs.

The cardiac and brain protocols were submitted for evaluation by participating countries in selected hospitals.

## **Radiotherapy**

Radiotherapy has remained of permanent interest in the region mainly due to its social and economical impact. Therefore, ARCAL has focused many projects related to a specific practice in this field. The main objectives of these projects have been:

- To identify the main difficulties and needs of the countries in the region, determining priorities and solutions.
- To promote regional co-operation among the institutions dedicated to cancer studies.
- To establish Quality Assurance Programmes.
- To set up Reference Centres for training in the region.

Related to the improvement of quality of radiotherapy practice, the following achievements were achieved:

- Three regional training events on clinical quality assurance for radiotherapy technologists. A total of 73 radiotherapy technologists participated in the three events.
- A total of six clinical protocols were prepared for the treatment of the most common forms of cancer in the region which contribute significantly to the death rate from this disease. These protocols include the following:
  - ◊ Accelerated hyperfractionation for head and neck tumours
  - ◊ Treatment of carcinoma of the endometrium by radiotherapy
  - ◊ Radiotherapy of non-advanced prostate cancer

- ◇ Treatment of cervical carcinoma following established quality control standards
- ◇ Conservation treatment of breast cancer with radiotherapy
- ◇ Segmental body irradiation in metastatic diseases
- Brachytherapy teams were supplied with caesium sources to replace radium needles in cancer treatment in the countries where such needles were still being employed. In the case of Peru, the use of radium needles was reduced by 50%. In the other countries, radium needles are no longer used for cancer treatment.
- A total of 24 cobalt units no longer meeting standards were replaced.
- A regional training event on implementing Quality Assurance Programme in radiotherapy (physical aspects) was held. Fourteen people participated in this event.
- The second group of medical physicists commenced the training (eight people).
- A group of experts from the region prepared a document entitled “Physical Aspects of Quality Assurance in Radiotherapy”, which is currently being used in selected hospitals of different countries participating in the project. The IAEA prepared a TECDOC on this topic based upon on the work of ARCAL.
- Two subcontracts (US\$80,000) were signed with the M.D. Anderson Hospital in the United States of America for the use of experts from that hospital in the event of an accident or incident occurring in the countries of the region which might call for such services.

Specifically in the Caribbean region, the implementation of ARCAL XXX, (RLA/6/032) “Improved Quality Assurance in Clinical Dosimetry for Radiation Therapy” led to the following accomplishments:

- Six audits were made in six countries with radiotherapy centres. It was found that all countries had developed sufficient experience to promote their own auditing function, and the majority of the hospitals associated with ARCAL XXX, (RLA/6/032) “Improved Quality Assurance in Clinical Dosimetry for Radiation Therapy” had been implementing the quality control procedures for evaluation. The most important conclusions that came out of these audits were:
  - ◇ All participating radiotherapy centres were included in the regular programme of auditing visits promoted by the project.
  - ◇ All participating countries developed the necessary experience for the implementation of their own auditing.
  - ◇ All participating radiotherapy units were revised and calibrated for the patients’ safety.

- ◇ The majority of radiotherapy centres participating in the project had assigned the necessary qualified personnel and the required resources to implement systematically the controls established by the Quality Assurance Programme. Only two cases showed significant personnel limitations.
- ◇ The majority of hospitals involved with the project were putting into practice the quality assurance controls elaborated under the project, although in a few cases the procedures had to be improved.
- ◇ Eight hospitals associated with the project experienced some difficulties during the implementation of the project; in some cases it was due to the delayed delivery of equipment and in others it was associated to excessive work in such centres.
- Seventeen medical physicists from the Caribbean were trained . One specialist in dosimetry and an engineer were also trained.
- Twenty-six new medical physicists were added to the hospitals associated to the project, establishing the minimum needs to improve the patients treatment in radiotherapy centres of the region.
- All radiotherapy centres associated with the project were identified as having a computerised system for radiotherapy patient dose calculation.
- Seven radiotherapy units (Co-60) were replaced, following Project Co-ordinators recommendations. Five other units were scheduled to be replaced in a few months. This improved considerably the equipment conditions of a large number of hospitals associated to the project.

Experience obtained with the project in Central America and the Caribbean was expected to be extended to other sub-regions.

## **Radiobiology**

In the area of radiobiology, the ARCAL Programme began two important projects in 1999: one in nephrourology and the other regarding Hepatitis C.

In the case of ARCAL XXXVI, (RLA/6/037) “Standardization of Nuclear Nephrourology Techniques”, the main objective was set to reach agreement among the working groups in Latin America to establish norms and to standardise protocols for the diagnostic techniques in the area of nuclear nephrourology. The specific objectives were as follows:

- To elaborate, if the normalisation allowed it, co-operative works with statistical significance that validate the techniques in the region.
- To elaborate and to upgrade periodically a Manual of Norms and Procedures for specialists in nuclear medicine and for the clinical doctor.
- To generate the necessary references to mediate with the equipment-supplying commercial companies to consider including software programmes which would take into account the diagnostic requirements with unified criteria.

- To promote increased dissemination and trust in the methods of nuclear nephrourology as starting point for trying to have rationalisation and normalisation of results.
- To gather data of epidemiology, human resources, instrumentation and supplies that reflect the reality of the region.

The following fundamental activities were implemented as part of this project in 1999:

- Compilation of all the existing procedures in the countries of the region in the field of nuclear nephrourology, with the purpose of preparing a document (manual) which would include all the procedures acceptable to the participating countries.
- Preparation of the Manual of Norms and Procedures in Nuclear Nephrourology and also the corresponding Protocols.

The IAEA circulated the first version of the Manual to all the participating countries to obtain observations and comments. The definitive version of this manual should be submitted for approval by the IAEA and possible publication.

ARCAL XL, (RLA/6/039) “Screening and Diagnosis of Hepatitis C“ aimed to develop serologic methodologies of RIA for the diagnosis of the viral hepatitis C (HCV) and to implement them for routine screening in blood donor populations, clinical diagnostics and epidemic studies. In particular, the following objectives were determined for the project:

- To design screening models and confirmation of HCV in blood donors and patients in the participating countries.
- To evaluate the RIA reagents developed in the region for use to screening use for anti-HCV.
- To implement the recognised methods of screening and confirmation to determine HCV infection in participating countries.
- To promote implementation of screening for HCV to all blood donations to prevent hepatitis C post-transfusion in the participating countries.
- To provide diagnostic methods of HCV to be used in the classification of viral hepatitis types in acute and chronic cases, as a means to prognose epidemiological studies.
- To achieve the total or partial production of RIA reagents to be used in screening and confirmation of HCV in the participating countries.
- To use the data obtained about persistent HCV to make recommendations for prevention and follow-up policies, according to the possibilities of each one of the participating countries.

The following fundamental activities were carried out in this project during 1999:

- A regional training course to demonstrate and evaluate the application of isotopes as a methodology in the screening and diagnostic of HCV. A total of 12 people from nine countries participated in this event.
- HCV reagents were distributed by Costa Rica to carry out tests for this project.

## **Master Degree in Medical Physics**

A Programme of Master in Medical Physics was initiated to be implemented over a few years in the region with the objective to improve the quantity and quality of the medical physicists who work in the region. The following main activities were implemented:

- A group of regional experts prepared a programme for the organisation of the course of Master in Medical Physics for Latin America and the Caribbean.
- A group of regional experts prepared the test for acceptance into the programme.
- Nineteen candidates were selected for the course that began in Caracas, Venezuela, starting in March 2000.

ARCAL XLIX, (RLA/9/035) “International Basic Safety Standards in Medical Practices” was designed with a series of activities to improve the radiological practice through the application of the International Basic Safety Standards in the Medical Practices in each selected country. The following project activities were accomplished by the end of 1999:

- A regional training course on Radiation Protection for X-ray Diagnostics. A total of 15 people from seven countries participated in this event.
- Elaboration of the first version of the following Protocols:
  - ◊ Protocol of Quality Assurance for the General X-ray Units
  - ◊ Protocol of Quality Assurance in X Rays Intra-oral Dentistry
  - ◊ Protocol of Quality Control in Mammography
- Evaluation of five participating hospitals in the project, with the purpose of knowing the measures and actions required to properly apply the International Basic Safety Standards in these hospitals. The hospitals which were evaluated were: Hermanos Ameijeiras, Cuba; San Vicente de Paul, Colombia; José Joaquín Aguirre, Chile; General Hospital, Mexico; and Dos de Mayo, Peru.
- Preparation of guides for setting up a Programme of Quality Assurance in Radiological Protection and Safety in hospitals.

## **Treatment of Accidents**

The ARCAL Programme has been supporting activities to develop a programme of regional co-operation in radiopathology, in dosimeters and biological indicator calibration to facilitate the correct estimate of absorbed doses, as well as in taking therapeutic decisions in cases of accidental exposure. At the same time, there has been concern to identify reference centres to assist over-exposed patients, as well as to identify reference laboratories for dose estimation.

The main result expected from ARCAL XXXVII, (RLA/9/031) “Medical Treatment in Radiological Accidents” was the creation of a Regional System of Permanent Interaction in Radiopathology with four reference centres located in Argentina, Brazil, Chile and Cuba. These centres were conceived to offer co-ordinated advice and possible collaboration in cases of radiological accidents in the region.

The following fundamental activities were implemented until the end of 1999:

- A regional meeting to develop a training programme for medical response in cases of radiological accidents in the region. A total of four people participated.
- National training seminars on medical aspects related to radiological emergencies. More than 140 people participated in this effort.
- Preparation of a manual to provide assistance to persons handling accidents involving radiological materials and to identifying a planned response to radiological accidents.
- Elaboration of a document with biological indicators for medical intervention systems.

## Isotopic Techniques in Hydrology

In many hydrogeological basins of Latin America, the aquifers have experienced a permanent deterioration due to biological, industrial and agricultural contamination; very frequently affecting particularly neighboring areas to urban centres. Another phenomenon that adds to the deterioration of the aquifers is the intensive exploitation or over-exploitation of underground waters causing the permanent reduction of the levels, the formation of big depression cones and the extraction of deeper mineralised waters.

The salinity of aquifers in coastal cities, the reduction of water pressure due to pumping, or the flooding due to the appearance in the surface of phreatic water, generally polluted water, are very frequent problems in the Latin American countries.

Deteriorated aquifers as described above demand studies with isotopic techniques as well as with traditional hydrogeological and hydrochemical methods. All of these methods combined allow a better knowledge of the function of the hydrogeological system of the aquifers (hydraulic characteristics, flow, areas, as well as charging and discharging of natural and artificial volumes, sources and types of contamination), which enable better management, rational use and protection of underground waters.

In the search to solve some of these problems, ARCAL XXXI, (RLA/8/023) "Aquifer Characterization for Sustainable Management" was implemented with the following objectives:

- To determine the hydrogeological functioning of the selected aquifers in the region.
- To characterize the water quality and its suitability for human consumption.
- To improve the knowledge about the available underground water resources in quantity and quality.
- To evaluate the contamination and vulnerability of the existent water sources.
- To detect the current or potential contamination sources.
- To identify the means of pollutants transportation through the sub-soil.
- To elaborate plans of sustainable exploitation of the underground waters.
- To train professionals of the region.

The following activities were carried out under this project:

- Training of 17 professionals in a regional activity covering flow and transport of pollutants in underground waters.
- Implementation of four national events in four different countries on the use of isotopic techniques in hydrology.
- Organization of measuring and observation campaigns in selected aquifers, as well as sample analysis in designated laboratories.
- Processing and evaluation of the first group of test results.

## Reactor Safety

Some of the reactors of the region have been in operation for more than 30 years with different levels of utilization. The aging of research reactors depends heavily on the conditions of service and the degree of the installation usage. To reduce any system deficiencies and to make sure to satisfy safety requirements, a programme of aging management was initiated in the region, following the guidelines provided by the IAEA-TECDOC-792. Supplementing this task, efforts were made to increase the ability in the region to use a calculation program based on Monte Carlo techniques. These programs carry out, with a high degree of accuracy, nucleus calculations, determine the radiation flow affecting the materials and consequently determine their degradation due to irradiation. Additionally, these techniques allow the evaluation of experimental systems of common use in the reactors (neutron beams, BNCT), design of armored-platings and energy depositions.

ARCAL designed a project covering research reactor safety which began in 1999: ARCAL XLIV (RLA/9/033) "Safety of Research Reactors".

The objectives of the project were the following:

- To confront research reactor aging problems by setting up appropriate aging management programmes.
- To implement the requirements and recommendations of IAEA for the core and fuel management considering design, operation, and modification of reactors aspects.

The following fundamental activities were implemented within this project during 1999:

- Regional training for handling the MCNP-4B program. A total of ten people from five countries participated.
- A combined evaluation of the aging management programmes and the results obtained in their application, with the purpose of effectively adjusting the existing aging management programmes.
- Monitoring of the selected systems for the application of the Aging Management Programme, with the purpose of watching over the aging of the components, equipment and systems to evaluate the impact that aging has in the safety of research reactors and to adopt the necessary measures for the correction and mitigation of aging.

The implementation of monitoring systems in the region upgraded the application of mathematical techniques for vibrations and noise to forecast system failures. This programme has also served to complement aging management because it establishes a technical basis for maintenance programmes in systems of high complexity with little statistical data, which is the case of research reactors.

## **Environmental Applications**

The big cities of some countries in the region, such as Sao Paulo, Mexico City, Buenos Aires and Santiago, have a very critical problem with the quality of the air. The improvement of life quality of the population in those cities depends to a great extent on constant monitoring and on the identification and characterisation of the polluting chemical elements present in the atmosphere, a matter of concern of Agenda 21.

In the search for solutions to these problems, the ARCAL Programme began in 1999 ARCAL XXXIX, (RLA/7/007) “Determining Content of Atmospheric Contamination” to identify the content of air pollution in the above-mentioned cities. The main objectives of this project were:

- To identify the basic characteristics of the elements in the atmosphere in the selected cities of Latin America, using nuclear analytical techniques.
- To characterise the particles using Scanning Electron microscopy and Transmission Electron microscopy
- To strengthen human resources in environmental pollution techniques through training workshops.
- To provide appropriate information on toxic pollutants to the institutions interested in environmental pollution.
- To establish regional centres to identify the elements present in the atmosphere.

ARCAL XXXIX, (RLA/7/007) “Determining Content of Atmospheric Contamination” implemented the following activities in 1999:

- A regional training event for the identification and preparation of samples. A total of seven people from four countries participated.
- Design of a strategy to collect environmental pollution samples in the selected cities.
- Implementation of the sample collection campaigns approved in the Plan of Activities in the participating countries of Argentina, Brazil, Chile and Mexico, as well as the quality control activities, chemical analysis and results harmonisation.

## **Nuclear Information**

ARCAL XLII (RLA/0/017) “Regional Information Network in the Nuclear Field” was initiated in 1999 with the following objectives:

- To establish a formal framework to improve regional co-operation related to nuclear information.
- To agree to exchange nuclear information in a systematic and organised manner.
- To enlarge the nuclear information data in the countries of the region through the Units of Information (UI) using computer and telecommunications technology.
- To strengthen the participating Units optimizing their administration and management.
- To disseminate, at the regional and international levels, the scientific-technical production generated by the participating countries.
- To increase in number and quality the electronic version of products in the region.
- To increase registrations to the INIS database by the participating countries.
- To train and to upgrade the knowledge in information technology of staff working in the UI.
- To procure the equipment and computational programmes to meet the specifications and requirements proposed for the computer technology needed for the project.

The following fundamental activities were implemented this project up to the end of 1999:

- A regional training event which 14 countries participated, covering
  - ◊ Electronic transfer of documents;
  - ◊ Registration of documents to the INIS;
  - ◊ Promotion and marketing of services; and
  - ◊ Access and use of databases.
- Shared use of the wealth of periodic publications and conference docketts among the existing UI. Through this project, access to the catalog of periodic publications via Internet was facilitated which resulted in wider dissemination of information.
- All the UI were strengthened with the acquisition of equipment and training. The knowledge and use of the products and services of the network were increased.
- Dissemination at the regional and international levels of technical reports generated by scientists in the countries was increased through active participation with INIS and the inclusion of the documents in the collective catalogs and in national agreements.
- Establishment of a system for exchange of documents through electronic means (via Internet), among the UI of the 15 countries participating in the the project, supplementing it with the access to international systems of supply of documents. More than 1400 documents were exchanged in 1999.

- Support provided to the countries to process electronic registrations and to reach contacts outside of the region.
- Creation of a web site for the dissemination of information and access to the services and products of the network. The address of the home page is: <http://www.cnea.gov.ar/rria>
- Increase of registrations to the INIS from the countries of the region, as well as preparation of instruction forms (printed and/or electronic) in Spanish to help data entry. In 1999, 3154 registrations were sent (while only 2173 registrations were sent during the previous five years)
- Review of the manual for gathering scientific literature produced as part of the project.
- Translation of the INIS manual into Spanish, including a bibliography.
- Production of promotional material.
- Compilation of information on the accidents and nuclear incidents that occurred in Latin America and the Caribbean (available in printed form), as well as country information on nuclear laws, ordinances, resolutions, and regulations (available electronically).

## Conclusion

During Phase III of the ARCAL Programme which covered the period 1995 - 1999, ARCAL Members States and the Agency continued with efforts to strengthen the Programme for the benefit of the countries in the region. Among the measures taken to achieve the goal set were the following:

- ARCAL representatives adopted the use of the Manual of Procedures. This manual includes all procedures and basic documentation related to the implementation of the ARCAL Programme.
- Finalization of the review of the ARCAL Phase II pamphlet. This pamphlet was published in the first semester of 2000, and covers the period of implementation of the Programme from 1989 to 1994.
- Finalization of the application of the procedures for the nomination of the first group of ARCAL Designated Centres. The first group of Designated Centres was composed of 24 centres from nine countries in the region. In the First Meeting of ARCAL Representatives, held in September 2000 in Vienna, Austria, the Institute of Nutrition and Food Technology (INTA) of Santiago, Chile, was also recognised as ARCAL Designated Centre.
- Significant improvement of the co-ordination among the countries and in the Agency in each of the stages of the projects cycle. This has been an essential factor for the achievements reached by the Programme during Phase III.
- An increase in the level of commitment from the President of ARCAL, the Managerial Group and the participating countries in the whole process of planning, evaluation, execution and approval of ARCAL projects.
- Increased participation of all the countries in the preparation and execution of the Programme, as well as in the process to make key decisions related to the Programme.
- Significant growth in the level of implementation of the Activity Plans for each project, as well as increase in the utilisation of resources related to the plans.
- Use of the limited resources assigned to the Programme by the Agency based on agreements and growth of the impact in the socio-economic development of the region.
- Reduction of the general cost of execution of the projects, in particular, of the training activities.

Phase III of the Programme was especially significant, not only for the positive results obtained in the implementation of the projects, but mainly for being the beginning of the establishment and formal recognition of the ARCAL Programme as an Inter-governmental Agreement among the participating countries and in the Agency.

The indicators used to measure the results and the impact of the execution of the Programme in the countries of the region continued to increase from 1995. These results were not only superior to those obtained in the Phase II, but furthermore, were the highest since the establishment of ARCAL Programme in 1984.

It is expected that during ARCAL Phase IV, once concluded the process of ARCAL re-organization, efforts should be aimed at achieving greatest efficiency and effectiveness in the Programme.

## **Future Directions**

For Phase IV of ARCAL, a set of objectives and goals were established. These objectives and goals were revised during the Working Group Meeting of the Board of Representatives, National Co-ordinators and Managerial Group held in Buenos Aires, Argentina, in March 2001, and afterwards during the Second Technical Co-ordination Board Meeting held in Mexico in May 2001, some adjustments to these goals were proposed. The report from the Buenos Aires Meeting with the adjustments proposed in Mexico will be considered for approval during the Second Meeting of ARCAL Representatives in September 2001. The following are the current proposed objectives and goals for Phase IV of the ARCAL Programme:

### **OBJECTIVES**

- To extend the influence of the ARCAL Programme with the purpose of including projects conforming with the priority sectors set for the national development plans of the countries which will allow the application of nuclear science and technology in an effective and beneficial way to solve their problems and meet their needs.
- To achieve better results than the ones obtained in the third phase in the process of development of technical co-operation among the countries of the region, through the consolidation of the goals already achieved until now in this field and through the extension of the TCDC concept by including other sectors of interest for the region.
- To increase the regulatory and physical infrastructure to strengthen nuclear applications.
- To support training events and training courses on the application of radioisotopic techniques in hydrology and radiotracer industry.
- To achieve an appropriate level of qualification for professionals devoted to medical physics and radiopharmacy.

### **GOALS**

- To apply the Guidelines for the Planning, Design, Evaluation, Approval and Execution of ARCAL Projects and the Regional Cooperation Plan (PCR) for the preparation and approval of ARCAL projects.
- To propose that all projects included in the Programme in Phase IV could be classified as Models Projects or fulfil the characteristics for it.
  - ◊ Contribute to the achievement of the goals of ARCAL
  - ◊ Focus on the solution of problems considered priority by the PCR
  - ◊ Comply with the strategies of the Department of Technical Co-operation of the Agency
- To reach no less than 85% in the level of implementation of all Activity Plans of the projects that are included in Phase IV of the ARCAL Programme.
- To achieve an implementation rate of the ARCAL Programme budget superior to 80% in total at the end of every year during the development of the fourth phase.

- To establish two new Regional Centres for the maintenance and repair of x-ray equipment and for the updating of software for medical applications and to increase the use of the three existing centres.
- To achieve by the end of the fourth phase that the contribution to finance the Programme projects be more than 30% of the total of the required resources and to increase the levels reached in previous phases of the resources coming from external sources to the Agency.
- To achieve, by the end of the fourth phase that more than 80% of the experts required for the implementation of ARCAL are from the region and that at least 80% of the training that is required be carried out in the region.
- To achieve the full force of the ARCAL Intergovernmental Agreement before the end of the fourth phase.
- To adopt and apply the Manual of Procedures of ARCAL.
- To secure the necessary conditions in the region so that the main radiotherapy centres meet the minimum requirements of quality assurance: functional and recognised laboratories for dosimetric calibration in the country or in neighboring countries, a minimum number of qualified personnel in medical physics, radiotherapy and radiotherapy techniques, and application of TECDOC-1151 procedures in each centre.
- To standardise the application and validity of the guidelines and procedures elaborated by the ARCAL Programme in radiation protection.
- To establish at least one national laboratory for the repair and maintenance of nuclear instrumentation in each of the countries in the region.
- To apply in the region the model regulations for food irradiation, as well as the protocols of verification and related certification.
- To establish a qualified reference laboratory in nuclear analytical techniques in at least eight countries of the region.
- To conclude the preparation of the Manuals on Plant Nutrition, Soil and Water Management.
- To conclude the treatment protocols for certain types of cancers and to make them available to hospitals in the countries of the region.
- To complete the Harmonised Programme on Quality Assurance in Radiopharmacy and to make it available to the sanitary and nuclear authorities in the countries of the region.
- To complete the Nephrourology and Mammography Protocols and make them available for use in the countries of the region.
- To train more than 100 technologists in nuclear medicine through a distance learning training course.
- To qualify more than 50 operators for tissue banking using distance learning training and to provide them with the relevant materials for this training and to prepare the required guidelines and standards.
- To qualify more than 40 medical physicists through the ARCAL Master in Medical Physics project.