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Survey of the teaching and applications in radiochemistry in Latin American countries

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In this paper, a description is made of the survey that was undertaken, for the first time, about the situation of radiochemistry activities in the Region of Latin America, comprising twenty countries from South America, Central America and the Caribbean. It became clear from this study that very strong differences exist between the countries and that most of the nuclear facilities in operation, such as nuclear reactors, hot cells, radiochemical laboratories and cyclotrons are concentrated in seven countries, accompanied by research and educational activities. A detailed study of the situation and trends in the Latin American countries is presented, as regards teaching and other activities related to Radiochemistry, as well as a series of suggestions for preservation of knowledge in the field.

Introduction

By initiative of the International Atomic Energy Agency, a Technical Meeting was held in Antalya, Turkey, (10–14 June 2002), in order to discuss the situation of the teaching and applications in radiochemistry in Africa, Asia, Europe, Latin America and in the United States. The concern of the IAEA is due to the fact that previous studies have shown that a gradual decrease of teaching and training opportunities in radiochemistry has been occurring in Europe and in the United States since more than two decades.[1]

However, the application of radioisotopes in medical diagnostics and therapy and the use of isotopes and ionizing radiation in food and safety technology, in agriculture, water management, or the nuclear fuel cycle in the energy production, require expertise in radiochemistry and measurement of radioactivity.[1] There is already a shortage in qualified personnel for maintenance of nuclear power plants (NPPs), decommissioning, or safeguarding of existing fissile material (e.g., plutonium in the countries of the former Soviet Union). If no immediate action to preserve present knowledge and encourage young scientists to engage in nuclear chemistry and radiochemistry will be taken, the subjects might disappear in several industrialized countries within a few years.

In the present paper, a description is made of the survey that was conducted in Latin American countries, as regards the situation of teaching, research and applications of radiochemistry. Also informations were gathered about existing nuclear research reactors, nuclear power reactors, cyclotrons and other smaller facilities.

Survey of the situation in Latin America and the Caribbean

The survey made was concentrated on IAEA Member States situated in Latin America and the Caribbean, comprising the following countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela, totalizing twenty countries.[2]

The contacts were made via e-mail and letters, starting with the Atomic Energy Commission or similar organization in each country. In some countries, more than one person or organization were contacted, using personal contacts besides the official addresses provided by the IAEA.

In Brazil, several Universities and Research Institutes were contacted, special attention being given to the Institutes of the Brazilian Nuclear Energy Commission.[3]

In most cases there was quite a delay in getting response from most countries, so again contact was made, stressing the importance of obtaining data for this survey and the benefits that could come as a consequence of the future actions that will be taken with support of the IAEA, in order to improve the situation in teaching and applications of radiochemistry.

Finally, answers were obtained from eleven countries: Argentina, Brazil, Colombia, Chile, Costa Rica, Cuba, Guatemala, Ecuador, Jamaica, Mexico and Peru, which filled the questionnaire that was sent to them.

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It is clear that very strong differences exist between the countries and in some of them very little activity is undergoing in radiochemistry.

Only six countries in the region have nuclear research reactors operating: Argentina, Brazil, Chile, Jamaica (Slowpoke), Mexico and Peru. The main reactors of Brazil and Argentina have powers from 2 to 5 MW and Peru has a research reactor with a maximum power of 10 MW. The RV-1 research reactor of Venezuela was constructed in 1956, went critical in 1960 and was shut down in 1994.

These reactors are mainly dedicated to radioisotope production, industrial applications, neutron activation analysis, and nuclear physics research.

Only Argentina, Brazil and Mexico have nuclear power reactors, as described below:

Argentina: Atucha 1 (335 MWe), Atucha 2 (692 Mwe) and Embalse (600 MWe)
Brazil: Angra 1 (626 MWe) and Angra 2 (1275 MWe)
Mexico: Laguna Verde 1 (680 MWe) and
Laguna Verde 2 (680 MWe)

Cyclotrons are in operation in Brazil, Argentina, Chile and Mexico, mainly for radioisotope production for nuclear medicine. These countries also possess electron accelerators for research and for medical and industrial applications. In Brazil, there are two cyclotrons operating for nuclear medicine purposes: a cyclotron Model Cyclone 30 at IPEN/CNEN-SP, for production of ^{18}F, ^{123}I, ^{67}Ga and ^{201}Tl and a CV-28, at the Institute of Nuclear Engineering, IEN, in Rio, for the production mainly of ^{123}I and ^{18}F. In Argentina, there are two cyclotrons in operation, both for medical purposes also, one at the Nuclear Medicine School in Mendoza and the other one at the Ezeiza Atomic Center.

Argentina has a cyclotron Model CP-42, installed in 1994, for production of ^{18}F and ^{123}I[4] and a cyclotron Model RDS 112, installed in 1997, for production of ^{18}F.

In Chile there is also one cyclotron in operation (IBA 18/9) for production of radioisotopes for nuclear medicine. At the moment it is producing ^{18}F and in the future ^{67}Ga.

Mexico has a cyclotron Model RDS 111, mainly for production of ^{18}F.

Brazil dominates the uranium fuel cycle, from enrichment of uranium by ultra-centrifugation to the production of U_3O_8–Al or U_3Si_2–Al fuel elements.

These fuel elements are produced mainly for future utilization in the nuclear power reactors, Angra 1 and Angra 2. These reactors utilize uranium enriched at 4% and until 2010 it is expected that the country will produce 60% of the uranium needed for Angra 1 and Angra 2. The nuclear research reactor IEA-R1 of IPEN uses uranium at a 20% enrichment, and this enrichment level is still not attained by the plants operating in the country.

Other countries, like Cuba and Peru, also operate hot cells, radiochemical laboratories, nuclear analytical laboratories.

As to radiochemical education, most of the activities are concentrated in three countries: Argentina, Brazil and Cuba, in the nuclear centers and in the universities.

In Argentina, a Post-Graduation Course on Radiochemistry has started in 1998, at master degree level, including courses and dissertation (collaboration between the Atomic Energy Commission and the National University of Technology). Also several universities have courses of radiochemistry in the faculties of chemistry, chemical engineering, biochemistry and pharmacy.

In Brazil, most of the courses related to nuclear sciences are conducted by the three main institutes of the Brazilian Nuclear Commission, in close collaboration with universities, and by the CENA-Piracicaba (University of São Paulo). The IPEN, situated in São Paulo, conducts the Course on Nuclear Technology together with the University of São Paulo, with 380 students enrolled in 2002. From 1995 until today, 244 MSc. degrees and 120 PhDs were awarded in this course and about 50 had some degree of relation to radiochemistry.

In Cuba, there are two main courses in the areas of radiochemistry and nuclear chemistry: Graduation in Radiochemistry and Master in Radiochemistry. From 1995 up to now, 244 students were enrolled in graduation and 36 in the master course and the number of degrees awarded were: graduation – 29; MSc – 22 and PhD: 8.

In the other countries that responded to the survey, there are generally brief radiochemistry courses in the universities.

In Table 1, a summary is given of the nuclear facilities existing in the region and of the number of radiochemists required until 2010. Also a summary is presented below of the suggestions given by the countries for preservation of knowledge.

Table 1. Summary of the nuclear facilities in Latin America and Caribbean and needs for personnel in Radiochemistry

Nuclear reactors	8 Research reactors (250 kW–10 MW)	8 Smaller reactors (10 W–40 kW)	7 Nuclear power reactors (335 to 1275 MWe)*	1 Slowpoke reactor (Jamaica)	
Cyclotrons	6 Cyclotrons for nuclear medicine		Argentina Brazil Chile	Mexico	
Other facilities	Hot cells	Electron accelerators Brazil, Argentina	Nuclear medical centers more than 650	Fuel element production units Brazil, Argentina	^{60}Co sources
No. of existing radiochemistry teachers or researchers	124	Argentina Brazil Cuba	Colombia Chile Guatemala	Mexico Peru	
No. of radiochemists needed until 2010	268		All countries that responded the questionnaire		

* Nuclear Power Reactors:

Argentina: Atucha 1 (335 MWe)
Atucha 2 (692 MWe)
Embalse (600 MWe)

Brazil: Angra 1 (626 MWe)
Angra 2 (1275 MWe)

Mexico: Laguna Verde 1 (680 MWe)
Laguna Verde 2 (680 MWe)

Conclusions

Suggestions for preservation of knowledge

Investments are necessary to keep and expand activities in the area – creation of a regional fund for radiochemistry activities.

Programmes have to start with courses for primary and high school teachers.

The quest for political support has to start by the Atomic Energy Commissions and go to the Chambers of Legislators.

International cooperation programmes have to be stimulated (fellowships for training and post-graduation).

Political support has to be asked to the Ministries of Education, to include chapters of radiochemistry in the textbooks.

Translation or writing in Spanish and Portuguese of good radiochemistry textbooks.

There is a need for better working opportunities for radiochemists.

Promotion of collaboration with more developed countries.

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