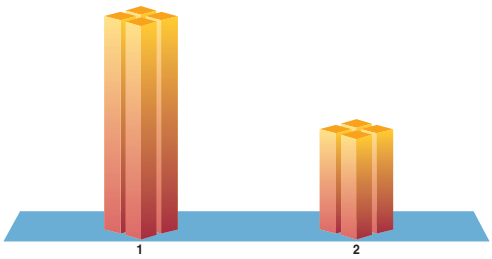
Physical and Chemical Applications

Objective

To increase Member State capabilities in the application of radioisotopes and radiation processing and as tools for sustainable economic development.

Regular budget expenditure:$2 253 170



1. Radiochemical Applications: $1 538 619
2. Radiation Processing, Radiography and Radiotracer Applications: $714 551

Key Issues and Highlights

- Improved electrodeposited targets were developed for the more cost effective production of thallium-201, the most widely used radioisotope for the diagnosis of heart disease, and palladium-103, an isotope with expanding uses in the treatment of prostate cancer.
- An educational package on computational fluid dynamics for the modelling of simple flows in chemical reactors was distributed.

Radiochemical Applications

Therapeutic radiopharmaceuticals and radioactive miniature sealed sources are new developments that have medical applications. Since the production and effective quality assurance of miniature sources can be technically challenging, a new CRP in this field was initiated. Twelve laboratories worldwide will study methodologies for the production of iodine-125 and palladium-103 miniature sources and the development of techniques and devices for assembling and sealing them, and for their quality assurance and control. As a result of research activities, the technology for preparing a very reliable thallium-203 target for the production of thallium-201, and a rhodium-103 target for the production of palladium-103 with copper backing, was developed. These targets result in high yields of the sources and more cost effective production.

Collaboration with WHO in the field of radiopharmaceuticals is being expanded. The development of publications on the production, specifications and quality control of radio-pharmaceuticals was identified as an area of co-operation between the two organizations. As part of the process, the revision of the general introduction on radiopharmaceuticals in the *International Pharmacopoeia* to reflect current developments was completed.

Research in the field of radioanalytical chemistry on new applications of prompt gamma neutron activation analysis (PGNAA) was initiated as part of a new CRP.

Therapeutic Radiopharmaceuticals

Recent advances in tumour specific peptides/monoclonal antibodies (MoAb), new radionuclides and bifunctional complexing agents have led to the development of a large number of radiolabelled biomolecules as potential therapeutic radiopharmaceuticals for the treatment of different cancers. The development of laboratory methods for the reliable and efficient comparative evaluation of promising therapeutic radiopharmaceuticals is important for the rapid identification of the optimal agent for treatment of a specific cancer. Research into developing reliable methodologies for comparing and predicting the effectiveness of therapeutic radiopharmaceuticals was initiated with the participation of 15 laboratories worldwide.

The participants, from nine Member States, are exploring new methods for the analysis of high technology materials, of large containers for examination of nuclear waste, and of pharmaceuticals and pure chemicals for light element contamination.

With the assistance of an expert group, the Agency assessed the state of teaching and applications in radiochemistry, including the educational status of radiochemists in Member States. The recommendations of the group addressed the continuing need for more radiochemists in the fields of nuclear power, nuclear waste treatment, nuclear medicine and industry. One response was to start a programme to develop electronic training tools in radiochemistry. Through technical co-operation projects, national capabilities in the preparation of reference standards were augmented in Poland and Brazil. Measurement capacity was upgraded in Tunisia and Greece through the delivery of advanced nuclear analytical equipment. Fellowships, expert missions and workshops were offered to enhance the quality of analytical procedures in nuclear laboratories in developing Member States. The promotion and implementation of quality systems is in accordance with ISO requirements to obtain national accreditation (Fig. 1).

The new *Analytical Quality Control Service (AQCS) Reference Materials Catalogue for 2002–2003* was issued in the first quarter of 2002. A total of 3000 copies were distributed during the year. The Agency's AQCS web site (*http://www.iaea.org/programmes/aqcs*) was made fully operational in 2002, providing on-line facilities for ordering reference materials and timely information for Member States. The web site has been receiving approximately 500 hits per month, and there are a growing number of on-line orders being placed for reference materials.

A feature of the AQCS is the organization of inter-comparisons and proficiency tests for use in research projects and in the technical co-operation programme. Examples in 2002 included proficiency tests for: the determination of alpha, beta and gamma emitting radionuclides in a soil matrix; samples in two different matrices (soil and cabbage); and the determination of trace elements in a soil and sediment matrix. Over 170 laboratories worldwide have taken part in the exercises. Additionally, orders for AQCS products to a value of $76 650 were received from approximately 200 customers.

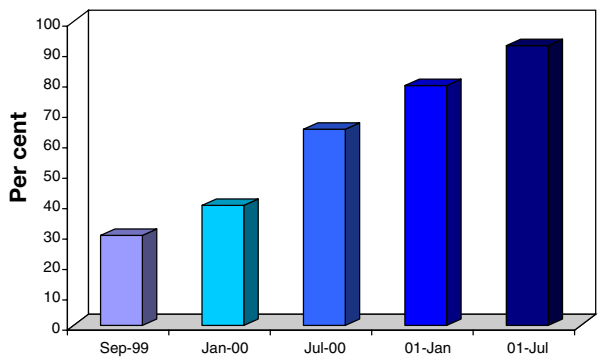


FIG. 1. Per cent compliance with ISO 17025 requirements for 12 laboratories in radiochemical analysis, 1999–2001.

Radiation Processing, Radiography and Radiotracer Applications

Taking advantage of new developments in radiation processing and electron beam technology, and in response to increasing demands for the development of promising environmental applications for the protection of human health and for water security, the Agency facilitated technology transfer to Member States through a number of technical co-operation projects and a CRP. The projects covered such areas as: the production of hydrogel dressings for medical purposes, manufacture of heat shrinkable materials for industrial applications, upgrading of electron beam accelerators for industrial applications and irradiation of sewage sludge for increased crop production.

The production and use of advanced composites, biomaterials and nanomaterials, and the processing of natural polymers were identified as emerging technologies in a series of expert meetings convened by the Agency. The experts concluded that for the modification of biomaterials, radiation technology can offer unique solutions in such areas as replacement tissues, unique polymer grafted cell culture surfaces, and the modification of nano-scale surfaces for applications in the emerging field of nanotechnology, such as biochips. In addition, a technical report was prepared on new analytical techniques for the understanding of radiation effects in polymers. The potential uses of analytical methods for the evaluation of the effects of radiation on organic polymers were considered from the following phenomenological viewpoints: molecular weight changes, oxidative processes, additives, low molecular weight products and weight changes. Reviews of recent developments involving the control of degradation effects in the radiation processing of polymers, and the use of ionizing radiation in the processing of natural and synthetic polymers were also carried out, and applications of these technologies for changing molecular weight and for bulk property and surface modification were identified.

Remediation of Polluted Water and Wastewater by Radiation Processing

Industrial and municipal activities can lead to the contamination of surface and groundwater. Radiation treatment, or a combination of radiation technology with conventional biological/chemical/physical processes, may help in the remediation of such contaminated waters. Owing to the importance of this issue, the Agency initiated a CRP with the participation of nine Member States. The results presented at the first Research Co-ordination Meeting have shown that the destruction of different compounds and biological contaminants can be achieved with moderate doses of radiation.

Promoting and supporting sustainable industrial growth in developing Member States is one of the objectives of Agency technical assistance programmes. Through a CRP, an educational package on computational fluid dynamics (CFD) was developed to model several simple flows in industrial processing units. The CFD–residence time distribution integrated software will help industry tracer groups to acquire more reliable information on complex processes, leading to the better design and optimization of chemical engineering reactors.

Overall, 2002 saw a range of new proposals for R&D projects in the field of oil production, industrial tomography and radioanalytical methodology. In particular, radioisotope technology has already produced significant results in oil production. For example, in Vietnam, the White Tiger oil reservoir was studied, with radiotracers being injected to help define an accurate flooding model. The optimization of water injection increased oil recovery by 3–5% and decreased operational costs, resulting in a large net benefit to the country.

The training and certification of personnel in non-destructive testing (NDT) techniques are key aspects in the building of a national industrial infrastructure. An updated version of *Training Guidelines in Non-destructive Testing Techniques, 1991 Edition* (IAEA-TECDOC-628), was published in 2002 to help streamline and harmonize training and certification schemes in Member States. In addition, more than 15 national technical co-operation projects were supported with the aim of establishing NDT centres, training staff and supplying equipment.

In the field of nuclear techniques for humanitarian demining, one device showed positive results in the laboratory and was selected for field tests under a regional technical co-operation project in Europe. The device, known as PELAN (Elemental Analysis by Pulsed Neutrons), was developed by a laboratory in the USA and weighs about 20 kg. It determines the relative concentration of carbon, oxygen, nitrogen and other elements in the anomalies identified by a metal detector, thus determining if explosives are present. Field tests at a dummy mine field in Croatia showed that the device, at its present state of development, is capable of identifying antipersonnel and antitank mines. Research groups in the Netherlands and the United Kingdom have been requested to look into the possibility of improving the sensitivity of this device. Another Agency research project has shown that handheld/portable systems based on neutron back-scattering, developed in the Netherlands and South Africa, hold promise for the detection of mines in dry soils.