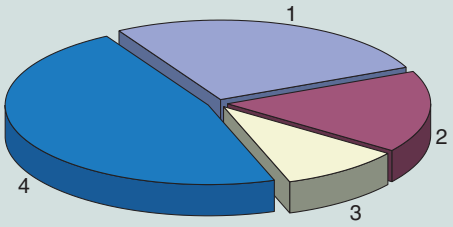
MARINE ENVIRONMENT AND WATER RESOURCES

PROGRAMME OBJECTIVE

To develop and foster the ability of Member States to gain knowledge of the temporal and spatial trends of radioactivity in the oceans and of the controlling processes, and to use isotopic and other technologies to quantify and evaluate marine pollution; and to integrate appropriate isotope and nuclear techniques in the planning and resource management of freshwater resources and gain a better understanding of human induced hydroclimatic impact on the water cycle and its interaction with other environmental systems.

Regular budget expenditure: $5 244 874

Extrabudgetary programme expenditure (not included in chart): $867 814



1. Measurement and Assessment of Radionuclides in the Marine Environment: $1 396 810
2. Transfer of Radionuclides in the Marine Environment: $877 078
3. Monitoring and Study of Marine Pollution: $515 828
4. Development and Management of Water Resources: $2 455 158

KEY ISSUES AND HIGHLIGHTS

- Several new techniques — including continuous in situ radioactivity monitoring — and facilities such as an underground counting laboratory and advanced aquaria for radioecological studies, were developed in the marine environment area. These provide significantly improved methods for the detection and study of both nuclear and non-nuclear marine pollutants in the laboratory and the field.

- In water resources management, the Agency assessed the present status and future directions for isotope applications in water cycle modelling, groundwater sustainability and the impacts of climate change on water resources.

- Efforts were made to link the Agency's R&D and technical co-operation activities to water sector programmes of the UN and bilateral agencies.

- A course was set up with Agency assistance on isotope hydrology in a post-graduate university programme on water resources engineering.

- The Agency was invited to be the UN system's lead organization to mark World Water Day in March 2002, in recognition of the impact of its programme of work in water resources.

MEASUREMENT AND ASSESSMENT OF RADIONUCLIDES IN THE MARINE ENVIRONMENT

In a project on 'Research on Worldwide Marine Radioactivity' (MARS) that ended in 2001, radionuclide data for sea water, sediment and biota were gathered during nine seagoing sampling expeditions organized by the Agency, through IAEA-MEL, and by its Member States. Eight anthropogenic radionuclides were chosen as the most abundant and representative in the marine environment, with the highest potential contribution to radiation doses to humans via seafood. The results indicate that the seas most affected by such radionuclides have been the Irish, Baltic, Black and North Seas. The data were added to the Global Marine Radioactivity Database (GLOMARD) and will be used as an international reference source on the average levels of anthropogenic radionuclides in the marine environment so that any contributions from nuclear reprocessing plants, nuclear power stations, former radioactive waste dumping sites, former nuclear weapons test sites and possible nuclear accidents on land or in the sea can be identified. The MARS project was supported by extrabudgetary funding by the Government of Japan.

A new technique for the investigation of radionuclides in the marine environment was developed at IAEA-MEL. Based on a state of the art underwater stationary gamma ray monitor with satellite data transmission, this technique can be used effectively for both short and long term monitoring of open seas, coastal areas, rivers and lakes. In specific cases, it can replace sporadic sampling campaigns and laborious analytical measurements in the laboratory as it can report real-time data, search for temporal changes and develop time series on radionuclide concentrations. In a joint operation with the Radiological Protection Institute of Ireland, the monitor, after being tested in Monaco Bay, was deployed in the northwestern Irish Sea.

Another innovation was the development, in cooperation with laboratories in Australia, Canada, France, Japan and the USA, of new radiochemical techniques for accelerator mass spectrometry (AMS). The new techniques can be used to analyse long lived radionuclides in the marine environment and have changed the focus of radionuclide analysis from counting radioactive decays to counting the number of atoms in a sample. The advantage of the latter method is its combination of exceptional sensitivity with minimum sample size, opening new frontiers in the study of oceanic processes using radionuclides as tracers.

An underground counting laboratory was constructed at IAEA-MEL for the analysis of radionuclides in marine samples at very low levels, with automated data acquisition and processing. Built using extrabudgetary support from the Governments of Monaco and Japan, the laboratory is situated 30 metres of water equivalent below the surface, where the flux of cosmic ray nucleons is reduced by about ten thousand times. Spectrometers operating in the laboratory in different coincidence–anticoincidence modes permit the analyses of ultra low concentrations of a wide range of short and medium lived radionuclides. This has important financial implications as the time needed for sampling work at sea can be considerably reduced. Valuable information can thus be obtained for assessing environmental radionuclide contamination caused by authorized radioactive discharges, accidental releases or terrorist actions.

The Agency's Analytical Quality Control Services (AQCS) programme continues to assist Member State laboratories in their quality assurance/quality control work (Fig. 1). Highlights in 2001 include: preparation of a seawater

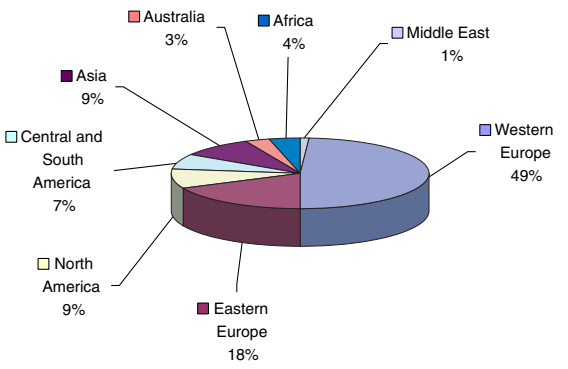


FIG. 1. Geographical distribution of the 184 laboratories participating in AQCS activities for radionuclides in the marine environment.

sample from the Mediterranean Sea (IAEA-418) for a new intercomparison run; preparation of a new intercomparison seabed sediment sample from the Irish Sea (IAEA-385); and completion of a regional intercomparison exercise for the Black Sea countries within the framework of a technical co-operation project and a regional proficiency test for the Baltic Sea countries.

As part of a regional technical co-operation project on the assessment of the contamination of the south Mediterranean Sea by radionuclides, heavy metals and organic compounds, a cruise was organized in coastal waters off Algeria. Seawater, sediment and biota samples were collected and several high resolution profiles of physical and chemical parameters, such as temperature, salinity and dissolved oxygen in the water column, were obtained. Based on the lead-210 chronology and the analysis of heavy metals in the sediment samples, it was concluded that concentrations of heavy metals in sediments in the southwest Mediterranean have been decreasing in recent years.

TRANSFER OF RADIONUCLIDES IN THE MARINE ENVIRONMENT

Nuclear techniques can improve understanding of the processes involved in transferring radionuclides and conventional contaminants through coastal marine environments. The focus in 2001 at IAEA-MEL was on tropical ecosystems: radiotracer experiments were carried out to investigate the bioaccumulation and retention of radionuclides and toxic heavy metals in key marine biota from tropical coastal environments. For economically important marine species like tropical mussels and oysters, the type of food ingested (different species of phytoplankton) was not found to be a predominant controlling factor in radionuclide and toxic metal accumulation, though salinity significantly altered bioaccumulation processes, with considerably higher uptake rates occurring at the lower salinities typically found in estuarine areas.

With the installation of new aquaria maintenance techniques at IAEA-MEL, the medium to long term culturing of tropical species with low mortality rates was successfully achieved. This has facilitated the study, for example, of the radioecology of the very fragile giant clam *Tridacna*, which lives in association with symbiotic microscopic algae (zooxanthellae) incorporated in the clam's tissues. It was found that these edible tropical bivalves readily bioconcentrate radionuclides and toxic metals, and that photosynthetic algae living in their tissues are likely to be responsible for a large part of the bioaccumulation of metallic contaminants in these clams.

The same aquaria maintenance expertise was used in another study that examined the trophic transfer of radionuclides and heavy metals, and their subsequent retention in three species of tropical fish which live in or near estuaries and tolerate a wide range of salinities. Among the contaminants investigated, only the ingested radionuclide caesium-134 was efficiently assimilated and retained, mainly in the edible flesh of these fish. In contrast, the ingested heavy metals cadmium-109 and americium-241 remained totally asso-ciated with the food during gut transit and were not incorporated into the fish tissues. The contaminant assimilation rate and subsequent retention of these radionuclides and metals in the organs of the fish were found to depend more on the element considered than on fish species or age. However, the retention efficiency of the heavy metals cobalt-57, silver-110m and zinc-65 differed significantly among species, suggesting a possible influence of digestive metabolism of the fish on the pollutant turnover rate in their tissues, a factor that should be taken into account when selecting species for fish farming.

Radiotracer experiments demonstrated that some marine organisms are able to retain accumulated pollutants for a very long time, making them very useful long term bioindicators of contamination that occurred several years earlier. One of these species, the common European crab *Pachygrapsus marmoratus,* was observed to have the ability to literally 'trap' a large proportion (more than 50%) of silver-110m ingested with its food. The results of tests performed in collaboration with several Member State laboratories suggest that this sequestration process involves the precipitation of silver as a non-toxic compound, and that such

metabolic trapping of this toxic metal may be a general feature among marine crustaceans.

In coastal zones, estuarine areas receive some of the highest inputs of anthropogenic contamination by trace metals. In areas where aquaculture is taking place, this situation has a potentially large socioeconomic impact, since many cultured bivalves like oysters are known to readily concentrate heavy metals from their environment, particularly the highly toxic contaminants cadmium, copper, zinc and mercury. A collaborative project funded by various French organizations, such as the Ministry of Agriculture and Fisheries and the Ministry of Research, and involving the National Centre of Scientific Research, the Faculty of Sciences of Nantes University and IAEA-MEL, was undertaken to develop radiotracer methodologies for determining the behaviour and fate of cadmium in commercial oysters originating from a cadmium contaminated estuary and those living in a clean area where cadmium contamination levels are low. The findings are of potential significance because they have led to the identification of adaptive cellular mechanisms, which help the organisms to 'adjust' to ambient cadmium contamination, and can also be used in the determination of the regulatory thresholds of cadmium concentrations in oysters.

Radiotracer studies are useful in placing constraints on the degree to which element ratios can be used as proxies to determine palaeoclimates. In this respect, strontium is an element of particular interest because of its involvement in biogeochemical calcification processes in marine organisms. For example, in tropical areas corals have aragonite–carbonate skeletons which contain relatively high amounts of strontium. Because the strontium/calcium ratio is thought to vary with seawater temperature, the ratio in coral skeletons has been proposed as a proxy for reconstructing past temperatures, a hypothesis based on the observation that there is a temperature dependence of strontium partitioning between sea water and coral skeleton. A collaborative project between IAEA-MEL and the Scientific Centre of Monaco used radioactive strontium as a tracer and found that the incorporation of strontium is inversely correlated with the rate of calcification. Thus, in the natural environment the incorporation of strontium in corals should depend on both the calcification rate and sea surface temperature. These findings suggest that specific metabolic interactions between strontium and calcium can alter the ratio, and this fact should be taken into account in palaeoclimate studies which use the ratio to infer past temperature regimes.

Natural radionuclides are important tools in tracing processes that govern carbon dioxide sequestration in the ocean and the role it plays in climate change. A new study using nuclear techniques to measure annual carbon export from surface waters was begun in the Mediterranean Sea near Monaco. Thorium-234, a short lived radionuclide which is produced continuously in sea water at a nearly uniform rate from the decay of uranium-238, becomes rapidly attached to carbon rich particles and is removed from surface waters with the sinking particulates. This preferential removal creates a disequilibrium between both radionuclides that is used, in conjunction with the measured organic carbon/thorium-234 ratio in the sinking particles, to estimate carbon export in the ocean. Measurements of the radionuclide profiles showed a significantly higher removal of dissolved thorium-234 in the upper 200 m in the early summer as compared with the spring. Furthermore, time series observations indicated that organic carbon fluxes derived from radionuclide concentrations were significantly different from the fluxes measured directly with sediment traps on a short time-scale (one to two days), but became very similar when data were integrated over a longer period of time (one to four weeks). Precise information on the downward carbon flux can be used to assess carbon dioxide removal from the upper ocean, a parameter that controls the transport of this greenhouse gas between the atmosphere and the ocean.

MONITORING AND STUDY OF MARINE POLLUTION

Techniques using inductively coupled plasma-mass spectrometry (ICP-MS) provide isotopic data that can complement conventional marine pollution studies. Lead isotopes have been routinely examined by ICP-MS for pollution monitoring programmes to provide source

information. In one application, sediment samples were evaluated for uranium and relatively high lead-206 concentrations to assess nutrient loading from phosphate rich fertilizers, which are generally associated with natural uranium. In another application of the same study, the measured lead isotope ratio was found to be the same as that used in leaded petrol from Morocco. Plutonium isotope data across depth gradients at a variety of locations have provided crucial information for assessing the fate and transport of plutonium in the marine environment. A pollution assessment project in the Caspian Sea examined uranium isotopes, unequivocally showing a different isotopic composition in the Caspian Sea from that found in the Black Sea and the Persian Gulf. More data are being gathered to draw conclusions on the significance of these findings.

Quality assurance programmes assist national laboratories in Member States and regional laboratory networks in obtaining reliable data for a range of non-radioactive marine pollutants (Fig. 2). Such assistance comprises intercomparison exercises, proficiency testing and training courses. Most notably, IAEA-MEL continues to be one of the few producers of marine reference materials. One sample, fish homogenate (IAEA-406), was certified following an intercomparison exercise in 2000 and introduced as a reference material for chlorinated pesticides, polychlorinated biphenyl (PCB) and petroleum hydrocarbons (PHs). Similarly, a sediment reference material (IAEA-405) for heavy metals and methylmercury was produced. In addition, IAEA-MEL prepared a pair of bivalve samples for ROPME (the Regional Organisation for the Protection of the Marine Environment) and two sediment materials for the Caspian Environment Programme.

Contaminant screening provides information on environmental quality that can be used in coastal zone management. A project that screened for trace inorganic and organic contaminants was undertaken in coastal areas in Oman in collaboration with ROPME. Generally the concentrations of organic contaminants in the waters and sediments were insignificant. With respect to biota, organochlorinated compounds, including those of agrochemical origin, were found at quite low levels. The only

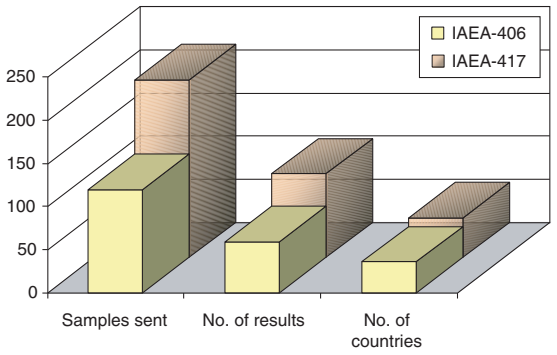


FIG. 2. The number of samples sent and the participants in two intercomparison exercises for organic contaminants: IAEA-406 (fish homogenate) in 2000 and IAEA-417 (sediment) in 2001.

bivalves showing some indication of oil contamination were the pearl oysters from Mirbat in southern Oman. As regards metals, of particular note were the extremely high cadmium concentrations in the livers of spangled emperor fish from southern Oman, the highest such cadmium concentrations yet reported. While anthropogenic contamination cannot be ruled out, the apparent enhancement may be due to food chain transfer of high levels of cadmium brought into the surface waters through the strong upwelling of nutrient rich waters that was occurring during the sampling period.

The Caspian Environment Programme (CEP) is an intergovernmental undertaking of the five Caspian littoral States, namely Azerbaijan, the Islamic Republic of Iran, Kazakhstan, the Russian Federation and Turkmenistan. IAEA-MEL collaborated with CEP on contaminant screening projects in Azerbaijan and the Islamic Republic of Iran in investigating a range of organic and inorganic pollutants in marine sediments from the coastal zone of the Caspian Sea. Petroleum hydrocarbon concentrations in Azerbaijan were quite high by global standards at some locations, notably to the south of Baku Bay. Recent inputs were recognized at a number of sites based on the weathering index. Whereas the polycyclic aromatic hydrocarbon (PAH) and PCB concentrations never exceeded sediment quality guideline values, numerous locations in the coastal zone of Azerbaijan had elevated concentrations of DDT related compounds, demonstrating the importance of organochlo-

rinated compounds derived from agricultural sources. With respect to metals, arsenic, chromium and nickel concentrations were quite high at several locations, but probably reflected high background levels. In contrast, anthropogenic inputs most likely accounted for the elevated copper and mercury concentrations in some hot spots. In the Islamic Republic of Iran, the PHs were weathered rather than fresh inputs and their concentrations in the marine sediments were generally lower than those found in Azerbaijan and were not especially high by global standards. Agrochemicals caused contamination of DDT at several sites and endosulfan sulfate exhibited a hot spot at one location. PAH and PCB levels were not sufficiently high to be of concern. Arsenic, chromium, copper and nickel concentrations were high, but probably of natural origin. Similarly, there was no evidence of cadmium, lead, mercury and silver pollution.

DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

Submarine groundwater discharge (SGD) is an important component of the continental freshwater balance and may be a significant source of nutrient and pollutant loading in coastal zones (Fig. 3). A new CRP was started on the application of isotope and nuclear techniques for monitoring SGD. As part of this CRP, a pilot study on SGD characterization was conducted off the Sicilian coast in co-operation with the University of Palermo, Italy, UNESCO's International Hydrological Programme (IHP) and the Intergovernmental Oceanographic Commission (IOC).

The IAEA/WMO Global Network for Isotopes in Precipitation (GNIP) is the primary database for isotope applications in hydrological and climate studies. Isotope monitoring of river water, which integrates the spatial and temporal variability of precipitation and hydrology on a catchment scale, greatly enhances the use of GNIP data and provides a robust new tool for evaluating the effects of climate change and land use patterns on water resources, as well as for developing integrated watershed management strategies. A CRP was initiated to formulate design parameters of such a global network for isotopes in rivers (GNIR) and will be implemented in close collaboration with WMO and UNESCO, as well as with international scientific programmes focused on continental scale water balance.

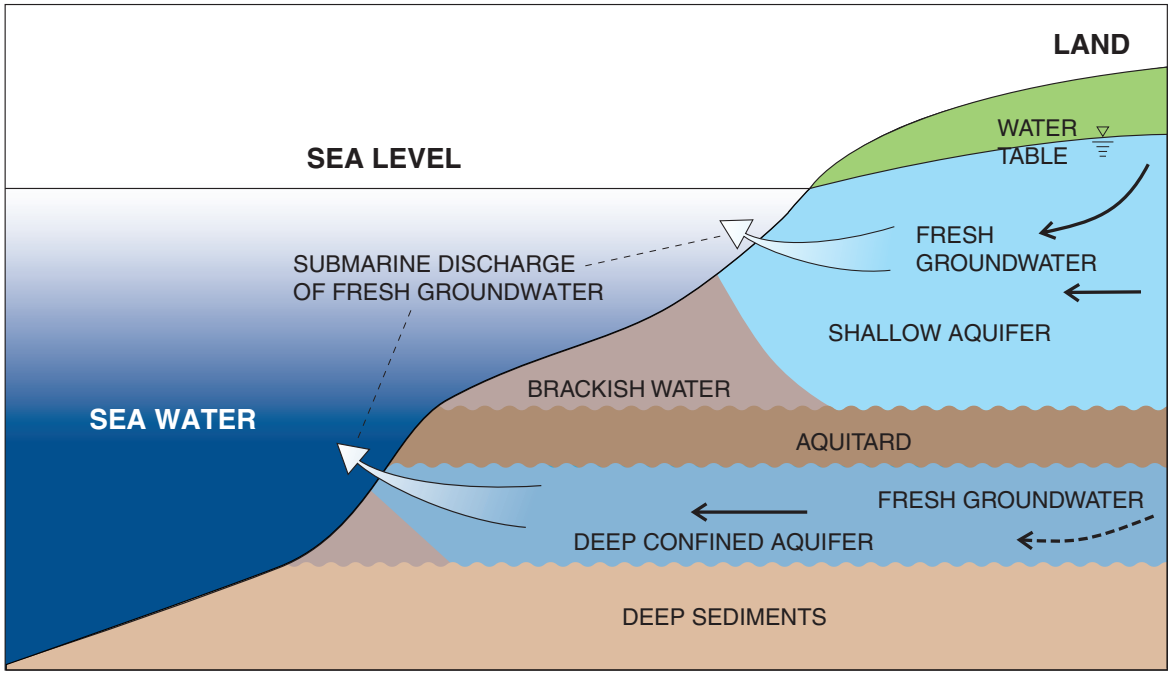


FIG. 3. Schematic representation of the submarine groundwater discharge process.

Nearly half of all fresh water for domestic use and irrigation around the world is derived from aquifers, linking the sustainability of groundwater resources to sustainable human development (Fig. 4). However, water resources in many parts of the world are severely stressed, as witnessed by declining water levels. The role of isotopes as indicators of groundwater sustainability was reviewed at an Advisory Group meeting held in co-operation with UNESCO. The meeting identified the complementary, but critical, role of isotopes in improving methods for groundwater sustainability assessment. Such methods are of great importance, given that current estimates of the world's water resources are generally weak as regards groundwater components, and no information is available as to what proportions of the groundwater bodies are renewable or non-renewable. As a follow-up to this meeting, a joint project with UNESCO was initiated to use extensive isotope data from aquifers worldwide, most which have been collected as part of Agency projects. The aim is to improve the understanding of the global distribution and amounts of non-renewable groundwaters, incorporating this information into a series of maps based on the Geographical Information System.

While it is widely accepted that recent global warming is largely a product of enhanced greenhouse gas (GHG) concentrations in the atmosphere, great uncertainty remains regarding the relationships between specific parameters and climate phenomena, and regarding the impacts of climate change on the Earth's water cycle. The scope of change observed in the last few decades appears to be unprecedented compared with the history of changes in the Earth's climate. Understanding the causes of past climate changes is, therefore, an important part of climate change research and isotopes are one of the most important tools to extend the spatial and temporal analysis of relevant climatic processes. An international conference organized by the Agency in Vienna in April discussed how isotopes could be used in environmental change studies. State of the art isotope techniques and their applications in global climate change research were reviewed and future research directions were discussed. Noting that isotopes are an indispensable tool for climate change research, the conference participants emphasized that the Agency has played a critical role in facilitating isotope based research and information dissemination. Moreover, the Agency's continued support was considered necessary to enhance the role of isotopes in large

FIG. 4. Global distribution of large aquifers with fossil groundwater.

scale, multi-disciplinary international programmes on climate change research.

One of the accepted mitigation options in the Kyoto Protocol for reducing GHG emissions is the sequestration of carbon dioxide by disposal in geological formations and in the oceans. A review of the potential role of isotope and nuclear techniques for designing and monitoring geological and oceanic carbon dioxide sequestration schemes found that leakage from deep underground storage reservoirs was a major concern for carbon dioxide sequestration operations, and monitoring was required to assess the integrity of the storage reservoir. Isotope techniques can be used to monitor the geological disposal of carbon dioxide in deep aquifers. However, a similar role in oceanic sequestration studies is more difficult, requiring a more precise definition of the problem. A follow-up activity to demonstrate the use of isotopes in geological sequestration studies is being formulated in co-operation with the Alberta Research Council in Canada.

A new regional technical co-operation project was started with the aim of applying isotope techniques in a Global Environment Facility (GEF) project focusing on the environmental protection and sustainable development of the Guarani Aquifer system in Latin America. The Guarani is a large freshwater aquifer underlying Argentina, Brazil, Paraguay and Uruguay, and isotopes are expected to provide critical input for strengthening the conceptual hydrological model of the aquifer. The Guarani project was approved for inclusion in the GEF work programme in December 2001, with the Agency's own technical co-operation project slated to begin in 2002. The World Bank and the Organization of American States are also participating in the Guarani project, together with national institutes.

In another regional techical co-operation project, significant achievements were made in developing and improving the management of groundwater resources in southern and eastern African countries. For instance, the sources of nitrate pollution in groundwater supplying the city of Dodoma, United Republic of Tanzania, were identified by using nitrogen isotopes and the results are being used to develop criteria for land use restrictions and groundwater

BOX 1. USING ISOTOPE TECHNIQUES TO MORE EFFECTIVELY MANAGE DRINKING WATER RESOURCES

One of the main themes of an Agency technical co-operation project on isotope applications for improved drinking water resources management is to improve the reliability of results obtained from numerical models of groundwater flow and solute transport by using isotope data. Among the highlights of this project were the following:

— A better understanding was achieved of groundwater recharge and pollution in the urban aquifer system near Lahore, in Pakistan, where isotope data showed that the deep aquifer was being recharged from the Ravi River. The isotope data were then used to constrain groundwater flow patterns obtained from numerical modelling. The results have provided a basis for local authorities to develop improved groundwater management strategies to reduce pollution of the aquifer, which is the primary source of drinking water.

— In Shijiazhuang City, China, nitrogen-15 analyses have been used to successfully identify the sources of nitrate contamination in groundwater in this densely populated area.

— In the Thung Kula Ronghia region of northeastern Thailand, isotope studies have been used to obtain the origin, age, recharge mechanism and flow dynamics of groundwater.

— Carbon-14 was used to constrain estimates of groundwater flow rates derived from numerical modelling. The combined use of isotope data and numerical modelling helped to improve the understanding of groundwater flow dynamics in the region. ■

protection. And local authorities in South Africa have indicated that changes will be made to the groundwater development strategies for the Taaibosch fault zone on the basis of the isotope results. These positive developments have heightened the interest of national authorities in Namibia and the United Republic of Tanzania in using isotope techniques for water resource assessments. Moreover, major international development projects in the region, such as the "500 Wells" project in Madagascar and the "Watershed Assessment" project in the United Republic of Tanzania, both sponsored by the World Bank, have integrated isotope applications into their programmes.

Agency technical co-operation projects seek to promote the use of nuclear techniques in Member State development efforts. One such project succeeded in increasing the integration of isotope hydrology into water resources management practices in China. A highlight was greater communication and co-operation between the various scientific agencies, where substantial capability in isotope hydrology exists, and the end-user agencies in China through the formation of a national co-ordination committee on isotope hydrology. This committee organized a workshop on the application of isotope techniques in water resources assessment and management in China and published its proceedings in English, with the support of the Agency, as a special issue of the journal *Science in China*. As a result of this increased awareness, the Agency is currently assisting various ministries in applying isotope techniques to groundwater resources assessment and management projects in northwest China. High priority is being given to the relatively large Erdos and Guanzhong groundwater basins, which are important regional development areas being promoted by the central government. As a follow-on effort, the Agency's technical assistance has been requested for integrating isotope techniques in managing river–groundwater interaction in the Black River Basin.

A programme of action for the IAEA–UNESCO Joint International Isotopes in Hydrology Programme (JIIHP) was formulated at an Agency meeting with seven national representatives of IHP. An operational plan was established setting out various activities leading up to the First JIIHP Steering Committee meeting that will be held in June 2002. In addition, the meeting set out a preliminary timetable and identified priority areas for the integration of isotope hydrology activities through the national IHP programmes that will be considered by the Steering Committee.

The urgent need to provide safe, clean drinking water to the world's population is bringing Member States and international organizations together in new partnerships that seek to maximize the benefits of their activities. For example, the Agency participated in the International Conference on Freshwater (ICF) organized by Germany. The objective of this conference was to focus world attention on freshwater issues and develop a common approach for the World Summit on Sustainable Development in Johannesburg in 2002. The Ministerial Declaration at the ICF called for greater efforts to improve the knowledge base for water resources management, and for more co-ordinated UN system activities in the water sector. Both of these items form the basis for much of Agency's programme in water resources development.

Another interagency effort was a workshop organized by the UN Economic Commission for Europe that examined the role of isotopes in the protection of aquifers used for drinking water supply. The objective is to revise and improve groundwater monitoring and protection standards in the European Union. One outcome of this effort was the decision to develop documentation on the use of isotope techniques for the characterization of protection zones for incorporation in the updated version of the European Union's groundwater monitoring guidelines.

The Agency has played a major role in building a cadre of trained isotope hydrologists worldwide (Fig. 5). In the past, the Agency emphasized training as continuing education, not as part of formal education at the university level. As a result, there is a continuing demand for human resources development even in countries where the Agency has built capacity in the past. A lack of sufficient academic training for hydrologists in the use and application of isotope techniques has been identified to be one of the major constraints that limit the integration of isotope

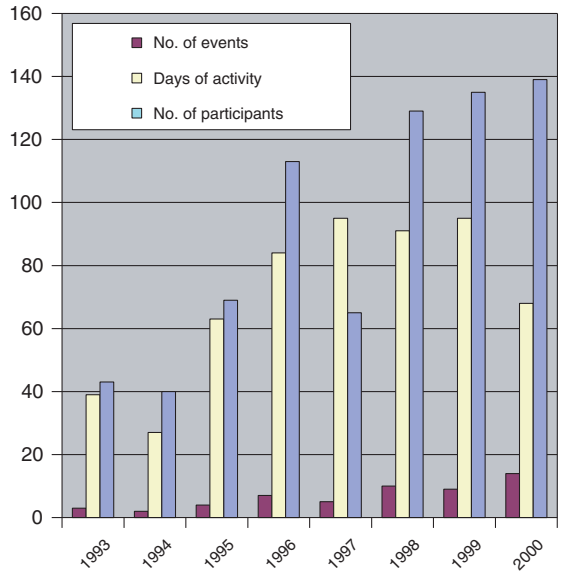


FIG. 5. Training courses and workshops offered by the Agency in isotope hydrology.

hydrology in the water sector of many developing countries. To help overcome these obstacles, the Agency provided assistance to the University of Roorkee, India, in organizing a semester course on isotope hydrology within its post-graduate programme on water resources management. This course is expected to serve as a model for similar courses in other parts of Asia. In addition, two institutes have been identified in Africa where isotope hydrology will be introduced into their post-graduate programmes.

In an Agency interlaboratory comparison to evaluate the quality of tritium analysis of water samples, the performance of less than half of the 86 participating laboratories was found to be sufficient for isotope hydrology applications in terms of accuracy and precision of measurements. Nearly one third of the participating laboratories had systematic errors in their analytical procedures. As a result of their participation in the exercise, 14 laboratories were able to identify and rectify internal analytical problems, as demonstrated by improvements in resubmitted results. Moreover, an overall improvement of 10% was recorded in the sensitivity and performance of participating laboratories compared with the last tritium interlaboratory comparison in 1995.

A network of analytical laboratories was established to assist in performing isotope hydrology analyses for technical co-operation projects. The network seeks to increase the participation of Member State laboratories in the Agency's technical co-operation programme while reducing the amount of routine analysis that needs to be performed. At present, the network includes seven laboratories, four from developing Member States. Continuous cross-checking of analytical results by the Agency ensures the quality of the services provided. In addition, the network ensures timely processing of analyses and serves as a means to widen or improve quality assurance schemes in Member State laboratories.