B
GC

GOV/2001/33-GC(45)/16
14 August 2001

GENERAL Distr.
Original: ENGLISH

International Atomic Energy Agency
BOARD OF GOVERNORS
GENERAL CONFERENCE

Sub-Item 17(b) of the Conference's provisional agenda
(GC(45)/1)

# USE OF ISOTOPE HYDROLOGY FOR WATER RESOURCES MANAGEMENT

## Report by the Director General

### I. INTRODUCTION

1. Resolution GC(43)/RES/16 requests the Director General "to report on achievements in implementing this resolution to the Board of Governors and to the General Conference at its forty-fifth session under an appropriate agenda item". Document GOV/2001/9, dated 9 February 2001, providing an overview of actions taken by the Secretariat in 1999–2000 with regard to a more extensive use of isotope hydrology in water resources management, was considered by the Board of Governors during its meeting in March 2001. The Board took note of the report and authorized the Director General to submit it to the General Conference at its next regular session with any necessary updating of activities undertaken during the intervening period. The present report is an updated version of GOV/2001/9.

### II. ACTIVITIES UNDERTAKEN IN 1999–2000 TOWARDS FULLER UTILIZATION OF ISOTOPE TECHNIQUES FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT

2. A two-pronged approach was used to direct programme activities towards fuller utilization of isotope techniques for water resources development and management. Research and development efforts under the regular budget were focused on increasing the use of isotope hydrology methodologies where isotopes offer a comparative advantage. Technical assistance to developing countries for the application of well tested methodologies was increased substantially and directed to be integrated as much as possible with national priorities.

#### Research and Development

3. New research projects for improving global water resources assessment and management by using isotope methodologies included the monitoring of submarine groundwater discharge (SGD) and of global rivers. SGD, which may be as much as 50% of the total terrestrial freshwater runoff, constitutes a substantial freshwater resource in coastal

areas and can be a source of pollution for the marine environment. The role of isotopes in the assessment of SGD was reviewed in collaboration with UNESCO's IHP (International Hydrological Programme) and IOC (Intergovernmental Oceanographic Commission). A combination of radioactive isotopes of radium and radon, and stable isotopes of oxygen, hydrogen and strontium, offer a nearly unique methodology for the assessment and quantification of SGD, which is difficult to achieve with non-isotopic methods. A co-ordinated research project (CRP) to develop and test isotopic tools for SGD has been proposed for 2002 in co-operation with the Agency's Marine Environmental Laboratory and UNESCO.

4. Isotope monitoring of river water provides an excellent proxy for the isotopic composition of precipitation and integrates the spatial and temporal variability in the hydrologic cycle. A global network to monitor the isotopic composition of river water can therefore be 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. Such a network of river stations will also supplement the long running IAEA/WMO's global network for isotopes in precipitation (GNIP) and increase the utility of isotope data for hydrologic and climate change studies. A CRP to formulate design parameters of such a river monitoring network, GNIR, has been proposed for 2002 in close collaboration with WMO and UNESCO.

5. Artificial recharge of groundwater is an increasingly used practice for improving the availability of drinking water. The present state-of-the-art in artificial recharge practices and the role of isotope techniques in process design and monitoring were critically evaluated. It was concluded that isotopes provide powerful tools to support global recharge enhancement practices, i.e. not only in arid regions but also elsewhere (notably the densely populated areas with heavy groundwater pumping, as in parts of Europe). Several locations with ongoing artificial recharge schemes were identified as potential demonstration sites where the use of isotopes can be integrated with other methods. This field of application will be vigorously pursued in future programmes.

6. Four CRPs were completed, resulting in improved isotope methodologies in the following areas. The outcomes of these CRPs will be of interest for water resources management in many Member States.

- *Radionuclide transport assessment in freshwater systems, particularly in areas affected by the Chernobyl fallout:* The research confirmed that Chernobyl radionuclides are present and mobile in regional surface water and fallout in terrestrial areas is largely restricted to the upper layers of humus soil even 14 years after the accident. Baseline information was developed that improved the understanding of radionuclide transport processes in aquatic and terrestrial environments, and the ability to simulate these processes.

- *Water quality assessment of surface water bodies impacted by sewage discharges:* One of the major achievements in this CRP was the application of dissolved oxygen isotope composition to quantify the processes of oxygen consumption and re-generation. Dissolved oxygen is the most important parameter influencing the water quality of surface water bodies, particularly when polluted with sewage or industrial water.

Sampling methods, micro-techniques to extract very low volumes of dissolved oxygen, and specific measuring techniques were developed.

- *The management and protection of aquifer systems in major urban areas:* Various isotope techniques were applied to characterize hydrological conditions in large urban centres in Australia, Bangladesh, China, Germany, India, New Zealand, Pakistan and South Africa. Primary applications where isotopes were most useful were for tracing artificial recharge, groundwater contamination and groundwater overexploitation patterns. Improved understanding of these processes would facilitate the assessment and management of groundwater resources in urban areas.

- *Geothermal exploitation:* The CRP resulted in validating isotope and geochemical methods for determining the origin of acidity in geothermal reservoirs. The outputs of the CRP are relevant to strategies for geothermal exploitation and some of the participating Member States have already benefited from their direct involvement in the CRP. The results are also useful for other countries which have the potential of encountering acidic fluids in their geothermal systems.

**Technical Co-operation Activities**

7. Technical assistance to Member States in the area of isotope hydrology has nearly tripled in the last five years to about $8.9 million for the 2001–2002 cycle. More than 52 technical co-operation projects in isotope hydrology were operational during the 1999–2000 cycle. Out of these projects, 26 were completed, and 39 new national and regional projects were included in the 2001–2002 cycle. Document GOV/2001/18 “Technical Co-operation Report for 2000” provides a more detailed account of technical co-operation activities related to water resources management.

8. A Thematic Plan was developed for the application of isotope techniques in dam leakage and sustainability studies. The planning process included consultations with relevant World Bank staff and the private sector. New technical co-operation projects for Asia and Africa have been formulated for rapid implementation of the plan. A group of experts was assembled to advise the Agency on the best means of integrating isotope techniques for dam sustainability studies.

9. A regional model project on “Isotopes in groundwater development” for north and west Africa was implemented in two phases for a total of six years. Four countries, namely Egypt, Ethiopia, Morocco and Senegal, participated in Phase I (1995–1998) and five countries, namely Algeria, Mali, Niger, Nigeria and Sudan, were participating in Phase II (1997–2000). Isotope hydrology applications resulted in improving the knowledge base of hydrological information for groundwater resources in all participating countries and in building local capacity for water resources management.

10. Following the successful implementation of regional projects in north and west Africa, a new regional project on “Sustainable development of groundwater resources” involving seven countries in southern and eastern Africa (Kenya, Madagascar, Namibia, South Africa, Tanzania, Uganda and Zimbabwe) was initiated.

11. Greater integration of isotope hydrology into water resources management practices was achieved in Ethiopia. A national plan for groundwater resources assessment in Ethiopia was formulated in a workshop organized by the Agency in co-operation with the US Geological Survey. A variety of governmental and non-governmental entities, including the Ethiopian Science and Technology Commission, the Ministry of Water Resources, the Ethiopian Geological Survey, Addis Ababa University, and consulting hydrogeologists, participated in the workshop. The plan formulated at the workshop is being submitted for government approval and, upon implementation, will guide the national and international efforts for groundwater resources assessment and management over 10–15 years.

## III. CO-OPERATION WITH OTHER NATIONAL AND INTERNATIONAL ORGANIZATIONS

12. A new IAEA/UNESCO programme initiative, Joint International Isotopes in Hydrology Programme (JIIHP), was launched to facilitate the integration of isotope hydrology in the water sector of Member States. JIIHP will allow a participation of and information dissemination to a wider group of practicing and research hydrologists in Member States through UNESCO's International Hydrological Programme (IHP) network. The JIIHP initiative was endorsed by UNESCO's Inter-Governmental Council for the IHP, and a Memorandum of Understanding to implement JIIHP is being discussed between the two agencies.

13. As a result of joint programming with other United Nations organizations, isotope hydrology was integrated in multilateral efforts for understanding the causes of and developing mitigation strategies for arsenic contamination in Bangladesh groundwater. The results of the work conducted in 1999 and 2000 provided a clearer definition of the hydrologic conditions and allowed the World Bank and others to evaluate the safety of deeper aquifers as alternative sources of drinking water.

14. At the request of, and in co-operation with, several United Nations organizations (WHO, UNICEF, UNDP), the World Bank and the Government of Bangladesh, a proficiency test was organized to evaluate the quality of arsenic measurements in about 20 laboratories in Bangladesh.

15. The IAEA/WMO global network for isotopes in precipitation (GNIP) was strengthened and expanded by greater collaboration with national institutions. The Scientific Steering Committee (SSC) for GNIP, instituted within the framework of a Memorandum of Understanding signed between the two agencies in 1998, allowed greater interaction with climate programmes of WMO. A technical document on network design is being prepared under the supervision of the SSC. This document will be the basis for increasing WMO's role in the collection of samples from existing stations and in new stations to be established for isotope applications to study the impact of climate changes on water resources.

16. Four of the six volumes of IAEA/UNESCO teaching material being prepared in the field of "Isotope Hydrology" have been completed and have been submitted to UNESCO for final publication as "Technical Reports Series" (an unpriced publication). The remaining two volumes are under preparation by the outside contributing authors and are expected to be printed in 2001. These publications are expected to considerably facilitate the dissemination of information on isotope hydrology in universities and training centres in Member States.

17. Increased efforts were made to develop trained human resources in Member States. Short term training courses in isotope hydrology were held in co-operation with UNESCO in Egypt, Japan and South Africa. Participation of scientists from developing Member States in international conferences and symposia was facilitated through sponsorship of the international symposium on isotopomers (Yokohoma, Japan), conference of the International Association of Hydrologists (Munich, Gernmany), and the scientific assembly of the International Association of Hydrological Sciences (Maastricht, Netherlands).

18. In co-operation with the University of Roorkee, India, a semester course on isotope hydrology was offered as a part of a UNESCO sponsored post-graduate programme in water resources management. This course is expected to serve as a model for initiating similar courses in other parts of Asia and Africa.

**Access to Isotope Analysis Facilities**

19. A new regional isotope laboratory was established at the Schonland Research Center, Johannesburg, South Africa. The two instruments that were provided (a liquid scintillation counter and a mass spectrometer) are being fully utilized. In 2000 the laboratory has analysed several hundred samples for the ongoing regional project in southern and eastern Africa. Several existing or upgraded laboratories (Algeria, Argentina, Egypt, El Salvador, Pakistan) also provided similar analytical support for technical co-operation projects.

20. A laboratory network is being established to further enhance the analytical capacity of laboratories in Member States. This will also reduce the level of routine analytical service provided by the Agency's laboratory, but will increase support for quality assurance and quality control procedures. It is expected that participating laboratories in this network will eventually be upgraded to regional resource centres.

21. A feasibility study for using an optical technique to measure stable isotope ratios in water was initiated in collaboration with Rutgers University, USA. Isotope measurement machines using the optical technique can be deployed with minimal infrastructure support and would have several advantages over the mass spectrometer techniques that are used today, including lower acquisition and maintenance costs, relatively low levels of operational skills and consumable items, and minimum infrastructure requirements. The optical measurement technique would substantially increase the ability of the Agency in strengthening Member State capacities for isotope analysis in a sustainable manner.

22. The provision of suitable isotope reference materials by the Agency continues to be a key requirement for ensuring reliable laboratory measurements. The quality of data produced by isotope hydrology laboratories was evaluated through two major interlaboratory comparison exercises for water stable isotope composition and for tritium activity measurements on environmental water samples. The tritium exercise is still ongoing. In both exercises more than 90 laboratories participated, which is a significant fraction of all active laboratories working in these fields.

23. Several interlaboratory comparison exercises for water chemistry measurements were organized in the framework of ongoing regional technical co-operation projects to strengthen the quality of chemical analyses in Member State laboratories supporting isotope hydrology

projects. The results from two subsequent exercises, carried out in 1999 and 2000, showed that about 30% of all laboratories improved their performance and provided more precise and accurate results than one year earlier.