WATER & ENVIRONMENT NEWSLETTER

A newsletter of the
Isotope Hydrology Section
International Atomic Energy Agency
Vienna

Issue 14, May 2001

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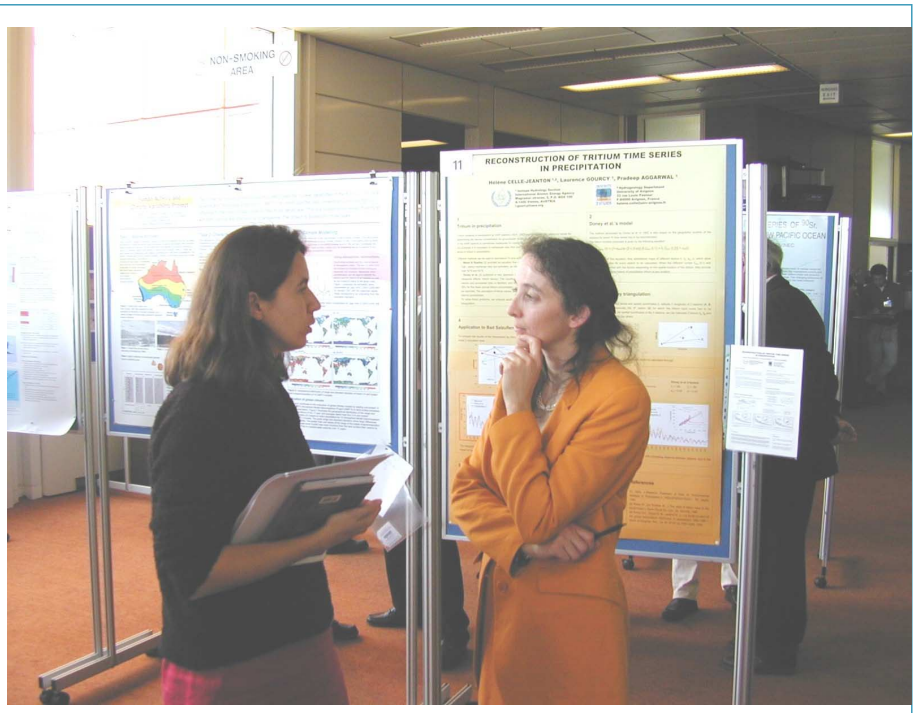

Participants in the poster display area during the International Conference on Environmental Change held April 23-27 in Vienna

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ISSN 1020-7120

FROM THE SECTION HEAD...

The IAEA has played a major role in developing isotope hydrology as a discipline and in building a cadre of trained isotope hydrologists world wide. In addition, Agency publications have served as a primary source of written material for training and education in isotope hydrology.

To date, these efforts for capacity building in isotope hydrology have focused on individual or group training of hydrologists who were active in research and field applications. More than seven hundred fellowships with an average duration of 3 months have been awarded over the last four decades for training at the Agency's Headquarters or at other established isotope hydrology centers. These fellowships have typically included some classroom instructions and intense interaction with one or more experts to develop skills in data gathering and interpretation. Group training events involving national, regional, and inter-regional courses of varying duration from one to eight weeks have been conducted with more than six hundred participants. Extensive on-the-job training has also been provided through technical cooperation projects.

Advanced training to participants from developing member states has also been provided through Coordinated Research Projects (CRPs). Some of the CRP participants may have received their initial training through fellowships supported by the Agency. A CRP affords a less experienced researcher the opportunity to improve his or her skills by interacting with others, including experienced researchers, while working on a common research theme.

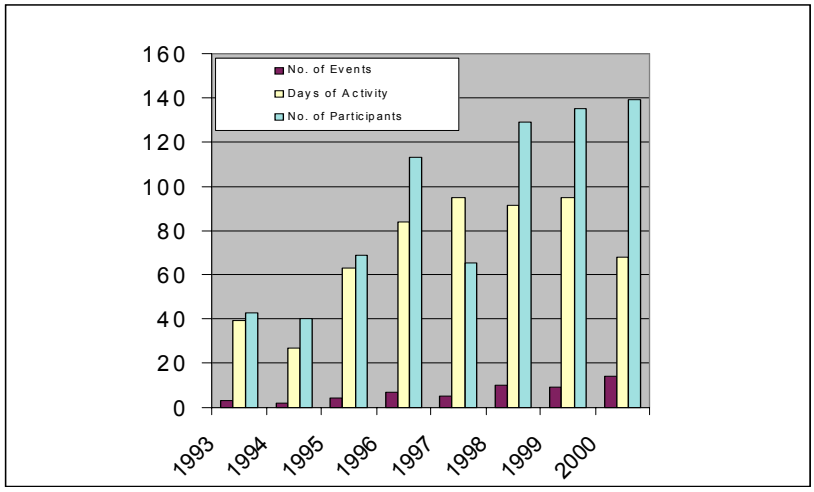

Figure 1. IAEA Training Activities in Isotope Hydrology

Availability of trained scientists with competence in isotope hydrology has improved the implementation of technical cooperation projects by interfacing indigenous capability with outside experts and developing capacity for related research. However, training events have been steadily increasing in recent years (Figure 1) owing to an explosive growth in technical cooperation projects. For example, 51 technical cooperation projects in isotope hydrology were completed between 1980 and 1990. This number increased to 141 for the period 1991-2000. Presently, about 56 projects are active for the 2001-2002 cycle, with two regional projects designed specifically for capacity building.

The increased demand for training in all aspects of isotope hydrology, even in Member States where such activities have been ongoing for many years, results largely from a lack of continuing transfer of imparted knowledge and skills to a new generation of hydrologists.

The Agency's training programmes in isotope hydrology have historically relied almost exclusively on continuing education. However, continuing education in a discipline can be more effective if basic training is included in the formal education phase. This warrants refocusing of the Agency's training to include formal education in isotope hydrology.

"Hydrologists" may come from a variety of disciplines such as geology, geography, civil engineering, agricultural engineering, chemistry, or meteorology. This academic background is often supplemented by post-graduate courses in hydrology. The International Hydrological Decade (IHD) launched by UNESCO in 1965 helped to develop a better appreciation for hydrology education. Post-graduate courses and then fully-fledged degree or diploma programmes were initiated in many institutions in both developing and developed countries through UNESCO sponsorship.

Considering the heterogeneous background of students attracted to hydrology programmes, it is important to design an isotope hydrology curriculum that meets the needs of the various students and is responsive to available job opportunities. Specialized educational programmes which do not enhance employment skills, would not attract students for long. Introductory topics in isotope hydrology should be included in hydrology-related courses in earth science and engineering schools to provide a basic exposure to the subject. A structured course in isotope hydrology should be included within postgraduate hydrology programmes.

Efforts to initiate isotope hydrology courses may initially target hydrology programmes begun under the auspices of or in collaboration with UNESCO in order to achieve easy integration into hydrology education. Agency-prepared and supplied teaching materials and necessary support for lecturers would minimize any financial impact to institutions choosing to include a course in isotope hydrology in their hydrology programmes.

An additional avenue for promoting isotope hydrology education at the university level is to sponsor chairs in Isotope Hydrology at selected universities. The sponsorship of these chairs would provide a higher profile to the awardee and enable him or her to serve as a magnet or focal point for national or regional educational and applied research activities.

Greater interest in scientific exchange and training perhaps can also be developed through longer-term and continuing linkages between institutions in developing countries and those in the developed countries. For example, an established isotope hydrology group may be asked to assist in conducting group training or university courses at a national or regional level. Selected participants from these events may then be provided a short-term group training in more advanced techniques at the cooperating institution. During this period, joint research or field projects may be identified that would be consistent with the host's research plans. Eventually, such institutional linkages will raise the skills and capacity at institutions in the developing countries to run some of the isotope hydrology courses on their own, with little or no external input.

The above strategy is expected to result in continually producing a large number of hydrologists who have been exposed to isotope applications. Many of these hydrologists would eventually develop a career in water resources management. These water managers would have the ability to view isotope techniques as an integral part of hydrology tool kits and, if necessary, to improve their skills through continuing education and training.

Pradeep Aggarwal

LONG TERM EXPLOITATION OF GROUNDWATER

The second Research Coordination Meeting on the Coordinated Research Programme (CRP) "Response of Hydrological Systems to Long-Term Exploitation" was held in Vienna from 2 to 6 April 2001. A total of 15 participants (13 contract holders, 1 costfree participant and 1 observer) participated in the meeting.

A number of hydrogeological investigations have been conducted using isotope and hydrochemical methodologies within this programme. A total of 14 participants (organisations) are involved in the programme and the aquifer systems investigated vary considerably. The overall objective of the programme is to assess the potential for utilizing long-term isotope responses of hydrological systems, especially groundwater aquifers. Through the years, physicochemical changes are expected in these systems due to heavy exploitation and other man-induced processes. The results will provide a long time-series of hydrochemical, isotope and geohydrological data which will be used for quantitative assessment of the long-term dynamic response of the system.

The meeting included present action and a review of results achieved to date within the various projects with a view to planning future activities. The expected outcome of the project as a whole as well as the individual contributions were discussed and partly re-evaluated. The planned final modelling exercises in the CRP were also discussed as well as specific requests, such as sampling, analyses and expert assistance for the individual participants. Several projects are still in the phase of sampling and analyses, however, the majority of the projects proceed according to the scheduled plan.

A group photo of meeting participants

One of the important conclusions of the meeting was that integration of different disciplines is essential for reconstruction and prediction of hydrological systems under long-term stress. That includes geochemistry, particularly for long-term available chemical data in water agencies, long-term hydrological data (e.g. water level record), a snap-shot geochemical and isotopic investigation, and numerical modelling. The numerical simulation should be based on field and isotopic data integrated with good information on the hydrogeological structure of the investigated system.

The different individual case studies can be divided into four thematic topics, for which it will be possible to establish general recommendations for future studies:

(A) Geothermal areas (Philippines, Turkey) – In thermal areas, long-term exploitation of fresh groundwater can result in lowering water heads and mixing with underlying hydrothermal waters.

(B) Arid areas (Jordan, Israel, New Mexico, India, Australia, Tunisia,) – In arid and semi-arid areas, long-term exploitation extracts more water than natural replenishment.

(C) Industrial area – (In this CRP, Germany) In industrial areas, the main focus of isotopic studies is to observe the infiltration of young polluted groundwater into older pristine groundwater.

(D) Subtropical area – (Malaysia)

The major outcome of the meeting was the future planning and suggestions for the CRP to consider how to proceed with the geochemical modelling and mathematical models. Further on, the fact that different individual case studies can be divided into four thematic topics and that guidelines with respect to standardising the individual presentation of the results should be considered.

For further information of this CRP, please contact Bill WALLIN at b.wallin@ieae.org.

ISOTOPE COMPOSITION OF PRECIPITATION IN THE MEDITERRANEAN BASIN IN RELATION TO AIR CIRCULATION PATTERNS AND CLIMATE

The first meeting of the Coordinated Research Programme (CRP) was held at the Agency's Headquarters from 17 to 20 April 2001. During these four days, participants from 14 countries presented their results of the first year of research on the study of precipitation using isotope fingerprinting. A hydrogeologist of the Geologisches Institut-ETH, Zurich, Switzerland and the head of the Physics of Weather and Climate Section of the Abdus Salaam International Center for Theoretical Physics (ICTP), Trieste, Italy, presented and discussed aspects of their research linked to the Mediterranean climate studies.

A group photo of the participants

Through international collaboration and the GNIP programme, 17 Mediterranean countries are monitoring precipitation in the Mediterranean basin. Thanks to collaborative participation of many nations, it will be possible to follow air masses through the basin and identify the isotope signal and interaction with various parameters (sea evaporation, continental and/or monsoonal air masses, coastal,...). In addition to the monthly precipitation sampling, it was agreed to perform, during a limited period of time, a more intensive rain and air moisture collection in order to improve the understanding of most particularly the characteristics and variability of d-excess, the processes controlling mixing layers, the extreme precipitation events and tritium variability in recent years.

For more information on this CRP, please contact Laurence GOURCY at l.gourcy@iaea.org.

GNIP/ISOHIS MERGED

The GNIP and the ISOHIS data were recently merged in a common database. This GNIP/ISOHIS database can be accessed through the Internet at the following address: http://isohis.iaea.org. The selection and download of the data is facilitated by a detailed research criteria function. In 2001, almost 8000 GNIP results and 6000 data on hydrogeological projects were added to the database. The Isotope Hydrology Section welcomes all external contributions to this database. All requests and data should be sent to isohis.feedback@iaea.org.

ISOTOPES: LINKING THE STUDY OF PAST AND PRESENT CLIMATE CHANGE

Climate change affects people, the environment, water, energy, natural resources and economy. It creates an uncertain future. As a result, it has become one of the most important issues on the world agenda. While it is widely accepted that recent climatic warming is largely a product of enhanced greenhouse gas concentrations in the atmosphere derived from post-industrial fossil fuel and biomass combustion, there still remains great uncertainty regarding the impacts of climate change on the Earth's water cycle. Although widespread environmental problems such as melting sea and glacier ice, higher surface air temperatures, intensification of weather patterns, ecosystem disruption, and rising sea levels are expected in an enhanced greenhouse climate, the magnitude of these changes is more difficult to predict. Mitigation of climate change is also problematic as changes may not be reversible due to interdependency of climate cycles and processes that have operated for long periods of time prior to human industrial activity. Climate change is not a new phenomenon, although the current scope of change seems unprecedented. Looking at the past record of climate change is therefore an important part of climate change research, and is the only direct way to separate industrial *versus* pre-industrial climate forcing. In this way, the past is the key to the present in the study of climate change.

Participants of the IAEA International Conference on the Study of Environmental Change using Isotope Techniques, held in Vienna, 23-27 April 2001

View of the conference in session

This was a recurring perspective expressed at the IAEA's Third International Conference on Environmental Change Using Isotope Techniques, which concluded on 27 April 2001 in Vienna. The conference, involving participation of some 146 experts from 39 countries and 7 international organizations, was the third such meeting held by the Agency, coordinated by the IAEA's Division of Physical and Chemical Sciences (NAPC) in Vienna, and the Marine Environment Laboratory (NAML) in Monaco. The meeting is an important global forum for presentation of results, discussion of ideas and concepts, for establishment of international collaboration, and collective identification of avenues for future research.

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Global climate change research is complicated by the longtime periods and large spatial scales involved. To some extent, climate change has been studied using instrumental records such as measurements of temperature, humidity, greenhouse gases, water levels, and glacier and sea-ice extent. Such records are important but they permit at the most a few decades or rarely over a century of environmental change information in selected locations where monitoring has been diligently conducted. As the earth system is inherently dynamic and old, it is difficult to unravel the fluctuations from the long term trends, and especially to identify reversible human impacts. In general, it is important to look beyond instrumental records to gain a wholistic perspective of the earth's climate and hydrologic system.

Isotopes, both radiogenic and stable, have been an important resource for the study of the Earth's climate, and have been widely applied as indicators of the water cycle in both the present and the past. They are like natural data-loggers or fingerprints occurring within the water molecule and within chemical substances and trace metals that are dissolved in water. In contrast to instrument based records, they provide long-term records of earth processes.

Regular meetings such as those held every four years by the IAEA help to ensure that technical developments and improvements in understanding present and past processes are widely known and can be rapidly incorporated into the collective methodology. The meetings support climate change research which is particularly important for its role in reducing future uncertainty and for identifying effective mitigation strategies for climate and environmental change.

Fourty-nine oral papers and 39 posters were presented at the meeting. Some research highlights are included below.

- Isotopes are being used as validation tools for predicting impacts of deforestation of the Amazon Basin and for examining the past isotope signals of El Nino events
- Comparisons between isotopes signatures in ice cores from low-latitude environments are being compared with those from polar ice cores, to evaluate causes and effects of regional versus global climate changes in the past
- Stable and radiogenic isotopes, along with non-isotope tracers such as CFCs are being used in the World Ocean Circulation Experiment to trace ocean circulation patterns, mixing, and residence times
- Isotopes are being used to study the past climate from aquifers in Europe, Asia, Australia, Africa, and the Americas
- New techniques are being developed for real-time monitoring of isotopic composition of atmospheric CO_2

APPLICATION OF ENVIRONMENTAL ISOTOPES FOR THE ESTIMATION OF SUBMARINE GROUNDWATER DISCHARGE

Introduction

The Submarine Groundwater Discharge (SGD) into the coastal zone has recently received increased attention and it is now recognized that this process is an important pathway for the diffuse transfer of contaminants such as nutrients, heavy metals, radionuclides and organic compounds from coastal zone aquifers into the near-shore marine environment. Coastal zones in many parts of the world are heavily populated and developed and aquifers in these regions often suffer from overexploitation and pollution. While the flows of major rivers of the world to the oceans are reasonably well gauged and analyzed, thus allowing comparatively precise estimates of riverine inputs to the oceans, it remains very difficult to evaluate the influence of direct groundwater discharge into the ocean. Determining the material fluxes and their impacts on the near-shore marine environment is difficult, as there is no simple means to gauge the groundwater flux. Indeed, within the last two decades a recognition has emerged that, in some cases, SGD may be both volumetrically and environmentally important to coastal zone processes. One such example is the occurrence of harmful algal blooms in the near-shore marine environment triggered by groundwater-derived nutrients.

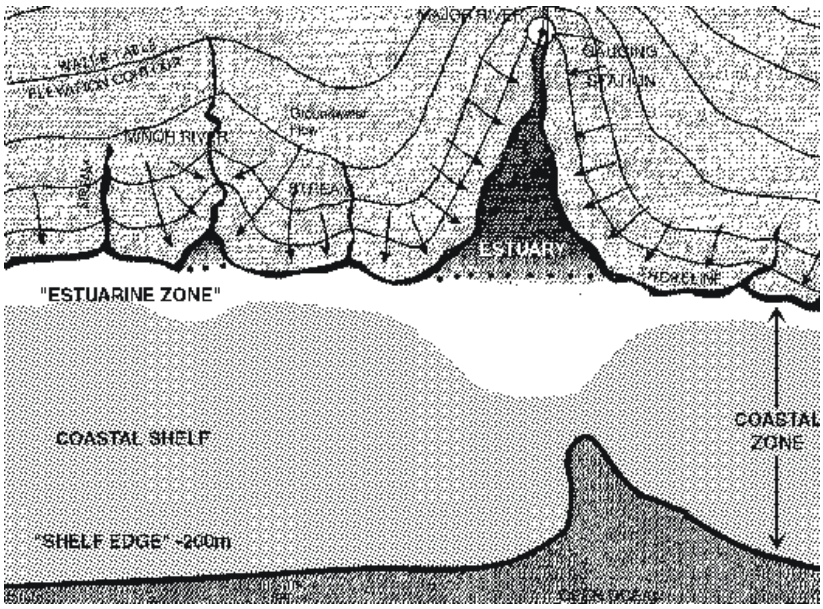

Figure 1 Plan view of a typical coastal zone, showing the relationships among the estuarine zone, open shelf zone, gauged and ungauged streams, and groundwater discharge to the ocean and to streams. Significant amounts of freshwater may seep into the coastal zone without measurement by the gauging station. Diagram taken from Buddemeier (1996).

SGD, coastal zone processes and applicable isotope methods

The slow, yet persistent seepage of groundwater through sediments will occur wherever an aquifer with a positive head is hydraulically connected to a surface water body. Thus, almost all coastal zones are subject to flow of groundwater either as submarine springs or disseminated seepage (Figure 1) and those adjacent to contaminated areas are likely to experience environmental degradation. Prior studies indicate that groundwater seepage is usually patchy, diffuse, temporally variable, and difficult to quantify. Furthermore, it is clear that he potential for discharging grou dwaters to have a significant impact on urface waters is greatest in regions where fluids may seep into a body of water having limited circulation.

Therefore, groundwater flows directly into the ocean wherever a coastal aquifer is connected to the sea. Furthermore, confined aquifers can extend for considerable distances from shore, underneath the continental shelf with discharge to the ocean at their points of outcrop. Figure 2 is a schematic diagram showing in vertical cross-section the major flux components in SGD at the land-ocean interface.

Because the isotopic composition of groundwater is typically different than the receiving coastal waters, SGD may be traced using a variety of isotopic and geochemical parameters. Figure 3 shows the same schematic diagram as shown in Figure 2 but indicating the applicable isotopic parameters that can be used to detect and estimate SDG fluxes and processes at the groundwater – seawater interface for estimation of SGD processes. The figure indicates some of the stable and radioactive isotopes that can be applied to the investigation of SGD.

The Agency's response to SGD issues

In order to meet the challenge of evaluating SGD, the Isotope Hydrology Section and the Marine Environment Laboratory (Monaco) jointly held an Advisory Group Meeting of international experts to assess the potential of isotope methods to the assessment of submarine groundwater discharge in August 2000. One of the main outcomes of this meeting was the recommendation to launch a Co-ordinated Research Programme (CRP) on nuclear and isotopic techniques for the characterization of Submarine

Groundwater Discharge. The focus of the CRP may be on coastal aquifer systems in the Mediterranean region, where there are many examples of concern over discharge of contaminated groundwater into the coastal zone.

The several objectives of the CRP may include:

- To develop isotope methods for estimating the magnitude of submarine groundwater discharge in coastal areas as it affects coastal oceanographic processes and on-shore groundwater environmental and water resources issues.
- To improve and develop new isotopic techniques suitable for describing the rates and magnitude of groundwater and salt water fluxes in coastal aquifers.
- To develop a better understanding of the influence of SGD on coastal oceanographic processes and the coastal and on-shore groundwater environment and water resources.

Links to other international programmes

One of the outcomes of the recent interest in SGD has been the establishment of a small group of experts "...to define more accurately and completely how submarine groundwater discharge influences chemical and biological processes in the coastal ocean". This working group (Scientific Committee on Ocean Research, (SCOR) Working Group 112, "Magnitude of Submarine Groundwater Discharge and Its Influence on Coastal Oceanographic Processes") is cosponsored by the Land Ocean Interface in the Coastal Zone (LOICZ) programme and the Intergovernmental Oceanographic Commission (IOC). The Agency's programme is being fully coordinated with the SCOR working group as well as with UNESCO/IHP and other international programmes to ensure a comprehensive approach to the application of isotope methods to SGD.

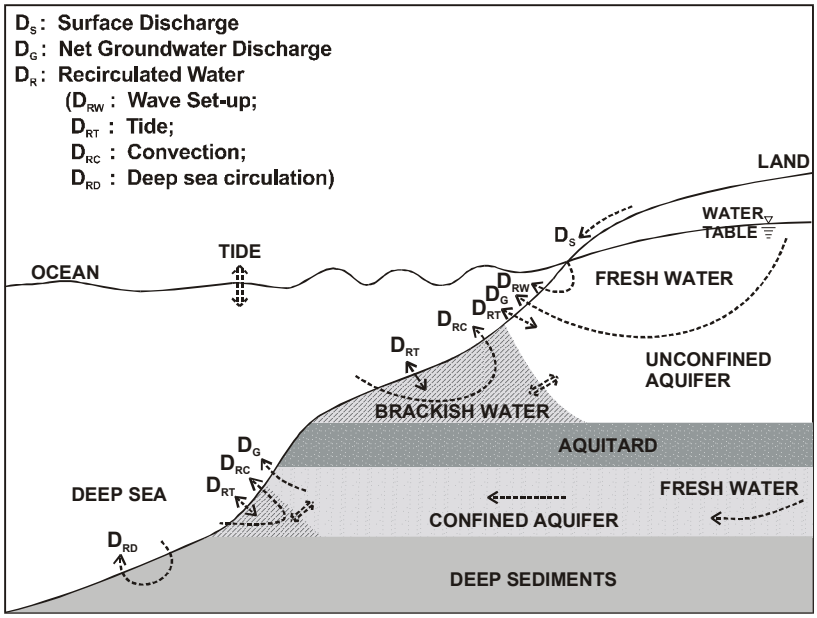

Figure 2. A schematic diagram showing in vertical cross-section the major flux components in SGD at the land-ocean interface

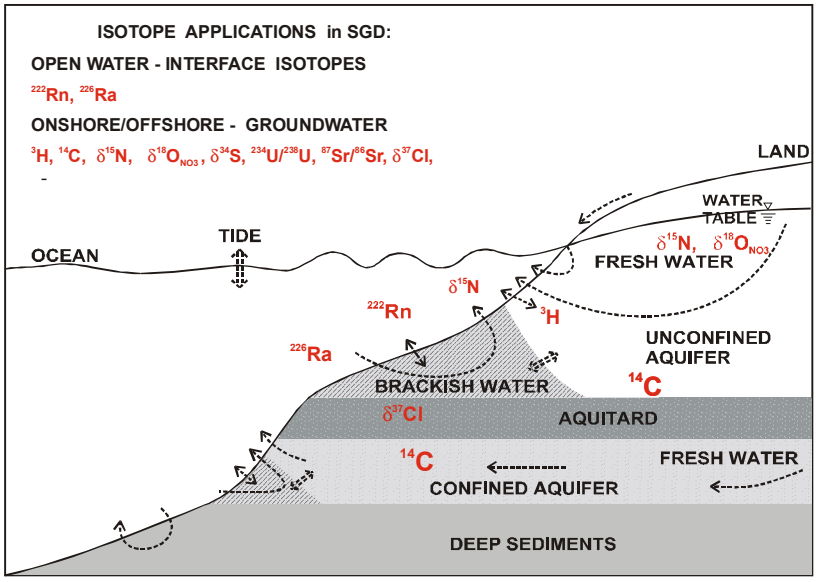

Figure 3. Isotopic parameters that can be used to detect and estimate SDG fluxes and processes at the groundwater – seawater interface for estimation of SGD processes.

The CRP is expected to begin in 2002. For further infromation please contact J. TURNER at j.v.turner@iaea.org

Reference

Buddemeier, R.W.(ed), *1996, Groundwater discharge in the coastal zone, Proceedings of an International Symposium, LOICZ Reports and Studies No. 8,* pp. 179, LOICZ Core Project, Netherlands Institute for Sea Research, Texel, Netherlands

INTER-LABORATORY COMPARISON ON GEOTHERMAL WATER CHEMISTRY

In the process of implementing technical co-operation projects in the field of geothermal resources development and mangement, it has been realized that chemical analysis on geothermal water samples is still a difficult field in many developing Member States. This imposes significant constraints on the application of isotope techniques to geothermal investigations. In order to improve this situation, inter-laboratory comparison exercises have been organized by the Agency on chemical analyses of geothermal water. The activitiy is open to all Member States with on-going technical cooperation project(s) in geothermal development and management.

The inter-laboratory comparison of geothermal water chemistry in 2000 was organized by the Agency in cooperation with the Government of Philippines through the PNOC Energy Development Corporation (PNOC-EDC). Thirty laboratories from Africa, Asia and the Pacific, and Latin America participated in this activity. The IAEA Isotope Hydrology Laboratory and four other laboratories were selected to serve as "Reference Laboratories".

The main objectives of the inter-laboratory comparison were: to measure the accuracy and precision of results of various chemical parameters in geothermal water analysis among the participating laboratories; to assess the improvement in the performance of the laboratories which participated in the previous inter-laboratory comparisons; and to identify areas of potential improvements for participating laboratories.

The increase in the total number of participating laboratories in 2000 signifies the growing interest of the geothermal community in ensuring that high quality results are obtained in the chemical analysis of geothermal waters.

The overall results of the inter-laboratory comparison in 2000 show that many of the labs which participated in previous inter-lab exercises have significantly improved their analytical quality, while others still need to strengthen their procedures of analytical quality assurance. As shown in figure 1, two thirds of the labs have either improved or remained good performance.

Annual interlab comparisons have been planned in the next two years within the framework of an IAEA interregional project on geothermal reservoir management for Africa, Asia and Latin America.

For further information on this project, please contact PANG Zhonghe at z.pang@iaea.org.

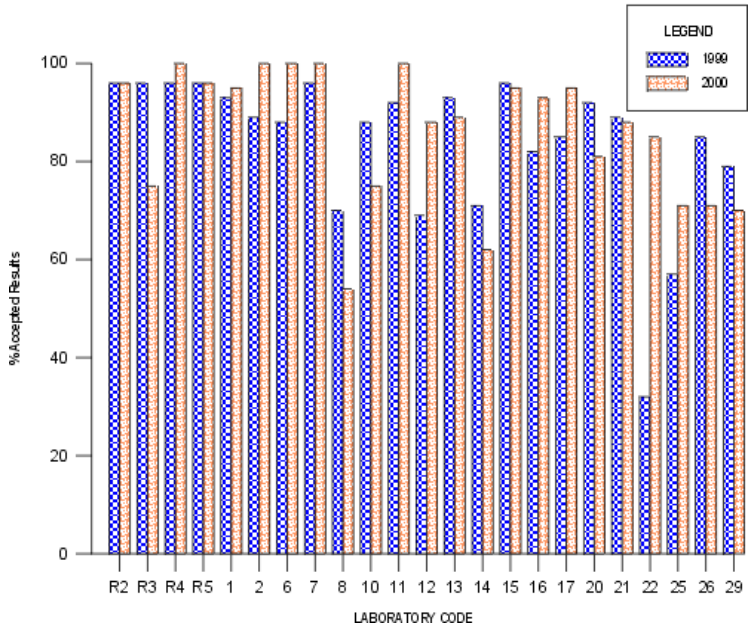

Figure 1 A comparison of the overall performance of participating labs in the 1999 and 2000 interlab excercises.

NEW STAFF MEMBERS IN THE ISOTOPE HYDROLOGY SECTION

Dr. John Gibson joined the Isotope Hydrology Section in January 2001 on a one-year term appointment to coordinate working groups and other section activities related to climate and water balance research. He has a Ph.D. from the University of Waterloo, postdoctoral experience with the University of Alberta and Environment Canada, and was employed as Lecturer and Adjunct Professor at the University of Waterloo prior to his appointment with the Section.

John can be contacted at **j.j.gibson@iaea.org.**

Dr. Jeffrey Vaughan Turner joined the Isotope Hydrology Section in February 2001. He has had extensive research experience in the application of isotope and hydrogeochemical methods to groundwater and surface water problems. Dr. Turner obtained his Ph.D. from Flinders University in South Australia followed by post-doctoral experience in Canada and the USA. Prior to his appointment with the Agency, he was a Principal Research Scientist with CSIRO Land and Water in Australia.

Jeff can be contacted at **j.v.turner@iaea.org**.

Dr. Bill Wallin joined the Isotope Hydrology Section in March 2001. He is a geochemist and has been involved in isotope studies in geochemistry and hydrology. During his career, Dr. Wallin has been involved in numerous international scientific pro–grammes, working groups and committees in the field of isotope techniques.

Bill can be contacted at **b.wallin@iaea.org**.

NEW IAEA PUBLICATIONS IN ISOTOPE HYDROLOGY

Several technical documents (TECDOC) have been recently released or are being printed by the IAEA. These publications can be requested free of charge from the IAEA distribution unit, subject to availability.

1. **Use of isotope techniques in lake dynamics investigations"**, Proceedings of a Coordinated Research Project.
   Code: TECDOC 1206
2. **Isotope techniques in water resource investigations in arid and semi-arid regions**, Proceedings of a Coordinated Research Project.
   Code: TECDOC 1207
3. **Isotope based assessment of groundwater renewal in water scarce regions**, Proceedings of a Coordinated Research Project.
   (in press.)

IAEA MEETINGS IN 2001

CM
Preparatory meeting to evaluate site requirements for a CRP on submarine groundwater discharge (to be proposed this year)
10-15 June, Sicily, Italy

AG-1124
AGM on the state of the art and development needs for noble gas isotope applications in geothermal reservoir exploration and monitoring
25-28 June, Vienna

AG-1125
AGM on Application of Isotopes in Water Cycle Models
27-29 August 2001, Vienna

AG-1127
AGM on Isotope Indicators of Sustainability in Groundwater Systems
15-17 October 2001
Vienna

RC
Application of isotopes to the assessment of pollutant behaviour in the unsaturated zone for groundwater protection
October
India

AG-1126
AGM on Isotope Applications in Integrated Climate System Studies
19-21 November 2001
Vienna

Water & Environment News, Isotope Hydrology Section,
International Atomic Energy Agency
Wagramer Strasse 5, P.O.Box 100, A-1400, Vienna, Austria.
Printed by IAEA in Vienna, July 2001

01-01431