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In this Issue

IAEA Water Resources Programme

Over 1 billion people lack access to clean drinking water

Photo: K.M.Kulkarni/IAEA

UN Decade for Action "Water for Life", 2005 - 2015

The integral role of water in international development has been acknowledged during the last two decades, with several international initiatives specifying goals that include water-related issues.

The United Nations proclaimed the period 2005–2015 as the International Decade for Action, "Water for Life", to place a greater focus on water. It recommits countries to achieve the water-related targets of the Johannesburg Plan of Implementation from the 2002 World Summit on Sustainable Development as well as the United Nations Millennium Development Goals set in 2000.

The IAEA, through its Water Resources Programme, is responding to global water issues, providing its Member States with science-based information and technical skills to better understand and manage their water resources.

From the Section Head

"With a Push from the U.N., Water Reveals Its Secrets" was the title of an article published in the July 26 edition of The New York Times. The article described the water situation in the world and laid out the fundamentals of isotope hydrology for the general audience. It also described the work of the IAEA in helping to avoid a water crisis. William Broad, a well-known science reporter for the Times wrote the article, which was well researched and lucidly written. This article topped the list of articles emailed by people reading the online edition of New York Times on July 26!

The Times article received global coverage and was reprinted in many local and national newspapers in the North America, Latin America, Asia and Africa. The Wisconsin Public Radio in the USA produced a one-hour call-in show based on the New York Times article. Overall, the news coverage was wide and positive. It resulted in introducing isotope hydrology to all kinds of people – a feat that is remarkable in itself and would be nearly impossible to accomplish on our own.

A primary motivation for the New York Times to publish this article arose from their surprise in learning about the Agency's work in this field while reporting on the nuclear non-proliferation issues. The reporter found a substantive programme on water resources that was helping to advance the science of isotope hydrology as well as making it available for use in member countries.

This recognition is in line with the constant increase in programme resources over the last several years and the interest of the member states in this programme. We now have a larger team of 26 professionals, technical staff, and support staffs who are contributing to make the programme successful. This year, we added two new professional staff in the programme and a full-time staff to coordinate the global data networks. As a result of these additional competencies, I expect that a number of new data products will soon be made available that will help to elevate the scientific interest in isotope hydrology and lead to greater integration with physical hydrology.

This year marks the 40th anniversary of the seminal paper by Craig and Gordon describing the isotope fractionation effects during evaporation. This paper has remained a centerpiece of all research related to isotopes in the water cycle. A special workshop will be held in Pisa, where Craig and Gordon presented their original paper in 1965, to review the present knowledge of isotope fractionation processes and future research needs. This workshop will be held during 3-5 May 2006 and will be hosted by the Institute of Geology and Geophysics and will be sponsored by the IAEA.

At the upcoming General Conference of IAEA member states in Vienna from 26-29 September 2005, a special event will recognize the international Decade for Action "Water for Life" proclaimed by the UN General Assembly from 2005-2015 and review the role of the IAEA in helping to meet the challenges of sustainable water resource management.

In preparation for this special event and to improve our communication in general, we have developed a number of public information materials and have developed a new format for the newsletter. The newsletter now aims to provide greater information on selected science issues and has a new layout. We also intend to regularly invite non-agency scientists to contribute short articles of general interest to the newsletter. If you are interested in a contribution, please contact us at ihs@iaea.org.

I hope you will find this edition of the newsletter useful and informative.

Pradeep Aggarwal

Global Environment Facility Approves Funding to Combine with an IAEA Technical Cooperation Project on the Nubian Aquifer

On June 20th, 2005, the Global Environment Facility (GEF) approved a $ 1 million grant to support activities led by the IAEA and UNDP for the shared Nubian Sandstone Aquifer System (NSAS) in northern Africa, one of the world's largest groundwater sources.

Joint Initiative for the Nubian Aquifer

UNDP and the IAEA will jointly manage the new activities, which will be combined with an IAEA technical cooperation project. The IAEA entered into a partnership with GEF in 2003 to develop this initiative.

The use of isotopic tools is key to gaining a sound technical understanding of this groundwater system, which covers about two million square kilometers beneath Chad, Egypt, the Libyan Arab Jamahiriya, and Sudan. The aquifer is very important as a source of drinking water and for irrigation. Setting up a framework for the management of the aquifer will support the region´s development as well as leading to better provision of drinking water and irrigation, lessening adverse effects on ecosystems, and improving control on desertification.

Putting Isotopes to Work

Since 2003, the IAEA has been helping the four Nubian countries to use isotope techniques to characterize the aquifer and to map available water resources. Estimates of the age of Nubian waters indicate that most water is over 20,000 years old and under present climatic conditions, the Nubian Sandstone Aquifer System (NSAS) is sparsely recharged. The IAEA project component aims to expand and consolidate the scientific knowledge and database on the aquifer as support to developing a groundwater management plan that should be based on a monitoring network for the aquifer.

The GEF funding will extend the scope of the IAEA-supported project activities to include:

- preparing a Shared Aquifer Diagnostic Analysis (SADA) to identify, understand and reach agreement on the priority issues, threats and root causes in the NSAS,
- filling key methodological, data and capacity gaps needed for strategic planning, using appropriate technical approaches with a focus on isotope applications,
- undertaking the preparation of a Strategic Action Programme to outline the legal, policy and institutional reforms needed to address the priority issues and their root causes as identified in the SADA,
- establishing an agreed legal and institutional mechanism towards a convention for joint four-partite management and rational use of the shared Nubian system.

Photo: R. Quevenco/IAEA

The Nubian aquifer is the only source of freshwater in Egypt's western district, which covers about 68% of the country's total land area.

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This is based on a recent IAEA web story on this topic http://www.iaea.org/NewsCenter/News/2005/nubian_aquifer.html

Isotopes Help in Assessing Water Resources in the Zarumilla Aquifer

Gaining a better technical understanding of the aquifer system is needed to support the management of the Zarumilla Aquifer, an important freshwater resource shared by Ecuador and Peru.

About 40,000 people live in the remote provinces of Puyango and Tumbes, located on the border that separates southern Ecuador and northern Peru. The river Zarumilla, which rises in the Andean Cordillera, forms this border, and runs here through semi-arid coastal zones.

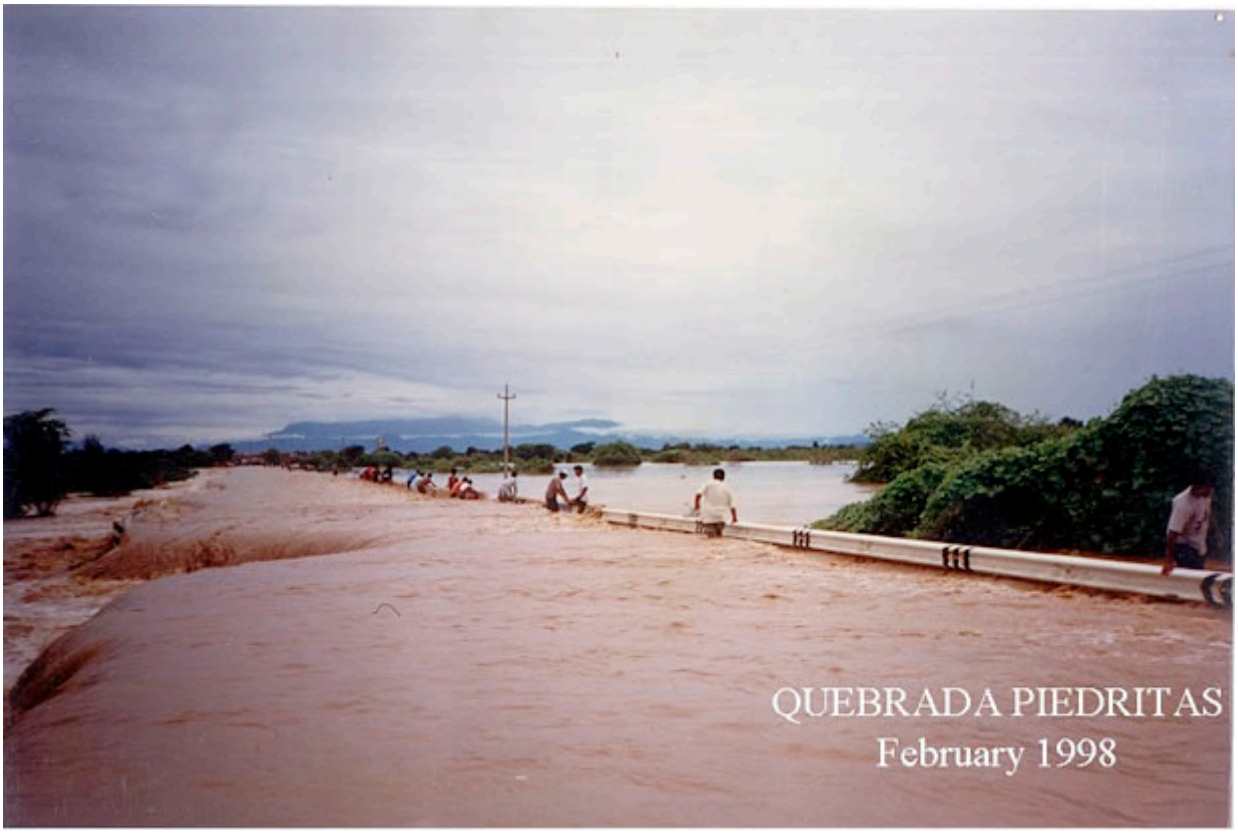
The aquifers of this river basin form a shared, trans-boundary groundwater system. The local climate and the recurrence of El Niño and La Niña, with their dry spells and extreme precipitation, mean that a clear understanding of the availability and character of both surface and ground waters is required for proper management of the often scarce resources. Moreover, a large irrigation project (50 to 70,000 ha) is being implemented in the basin.

As part of the assistance provided by the IAEA to the Special Project created by the Government of the two countries (the Special Bi-national Project Puyango-Tumbes, PEBPT), geochemical and isotope techniques (among other hydrological tools) are being used to evaluate surface water resources, to map the aquifer systems and to characterize the hydraulic properties of the groundwater bodies of the Zarumilla basin.

The IAEA-supported study has provided, for the first time, a consistent picture of the geology of the area and the main characteristics, in quantity and quality, of the available water resources.

Due to the zone's remoteness and past land conflicts, the exchange of technical information between the two countries and the co-ordination of the geological and hydrogeological studies were almost absent. This project has helped to establish teams to conduct the multidisciplinary work needed to assess the water resources of the basin. Technical staff from the two countries are conducting the studies,

Location of the study area in the Zarumilla basin between Ecuador and Peru



El Nino's effects are particularly significant in the Zarumilla area. Although huge amounts of rain sometimes fall (as here, causing flooding in 1998) rain is irregular and cannot supply the area's water needs. For this reason, groundwater supplies are crucial.

incorporating isotope techniques and numerical modelling as key tools for a proper assessment of groundwater resources.

Recharge – two different routes

Extensive hydrogeological mapping has identified two main aquifer units. The hydraulic connection between the two units – and their relation to surface waters – has also been established.

Isotope data showed that one of the aquifers is exclusively recharged by local precipitation and not hydraulically connected to the Zarumilla river. However, the second system, a shallow alluvial aquifer, is mainly recharged by surface runoff.

These facts have clear implications for the sustainable use and vulnerability to pollution of both systems. The study has also shown that groundwater recharge to the first aquifer is mainly local and derives from precipitation over areas located at a lower elevations than anticipated.

Besides the key role of isotope and geochemical techniques in understanding the flow patterns of the groundwaters, the project has also provided basic information for defining a monitoring network, as well as recommendations to the local authorities for sustainable management of water resources in this shared aquifer.

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News in Brief

New Staff Members

Mr. Andrew Herczeg joined the Section in February 2005 from CSIRO Land and Water, Adelaide, Australia. He is developing approaches to improve the incorporation of isotope hydrology into management of regional scale groundwater basins. The long-term response of hydrological systems (quantity and quality) to climate change, land-use impacts, water diversions and groundwater pumping is key to their sustainable use. Environmental tracers provide important time constraints as well as regional scale integration of process that are the foundation of management decisions. Mr. Herczeg is also interested in enhancing the Water Resources Programme's activities in groundwater-surface water interaction in arid and semi-arid regions, Managed Aquifer Recharge (MAR), and dating of groundwater on time scales of the order of tens to hundreds of thousands of years.

Mr. Luis Araguás-Araguás re-joined, after a break of seven years, the Isotope Hydrology Section in May 2005 from the Department of Hydrogeology at the Geological Survey of Spain. His duties will include the maintenance and operation of the Global Network of Isotopes in Precipitation (GNIP) and will act as Technical Officer on Technical Cooperation Projects dealing with hydrogeology and related fields, mostly in Latin American countries. He will also coordinate the maintenance of the Isotope Hydrology Information System (ISOHIS). His interests include studies dealing with the atmospheric processes and factors controlling the isotope signal of precipitation and the use of environmental isotope techniques for the assessment of groundwater resources.

Mr. Turker Kurttas joined the Isotope Hydrology Section in May 2005. He was formerly Assistant Professor at the Hydrogeological Engineering Department of the Hacettepe University in Turkey. His interests include the application of environmental isotope techniques to groundwater and surface water studies. In the Section, Mr. Kurttas will work on Technical Cooperation Projects related to sustainable water resources management using isotope techniques, e.g. dam safety and sustainability, monitoring landslide activity, and groundwater studies in karstic areas. He will also work on analysis and maintenance of global isotope data related to groundwater, river and precipitation networks (including GIS based applications of the Section's databases) and on producing thematic maps of the hydrologic cycle components using these databases.

Mr. Seifu Kebede Gurmessa joined the Isotope Hydrology Section in July 2005. He was formerly a doctoral fellow at Universite d'Avignon, and lecturer at Addis Ababa University. He has worked on isotope hydrological and paleo-hydrological studies of Ethiopian lakes, and is interested in the application of isotopes to the study of tropical lakes, reservoirs and wetlands (including quantitative isotope budget and evaporative flux determinations). Mr. Kebede will work on an isotope database for Africa under the ISOHIS program. He will assist in the preparation of guidelines for isotopic studies of the African Lakes, particularly those lakes and wetlands within or in the vicinity of the Nile River Basin. The guidelines aim to develop models for hydrological investigation of lakes in the Nile and Sub-Saharan Africa.

Mr. Timothy Chavez joined the Isotope Hydrology Section in May 2005 as Data Coordination Clerk. Mr. Chavez was formerly in the Operations of the Department of Safeguards. In the Isotope Hydrology Section, Mr. Chavez will assist in the operation of isotope networks (GNIP, rivers, air moisture, etc.) with monitoring stations. This will include conducting data quality and consistency checks in the preparation of data products and synthesis reports, record water sample analyses into the computer database, which has been received directly from the Agency's laboratory and collaborating laboratories. He also assists in production of the Section's newsletter and management of the Section's web page.

Departing Staff Members

Mr. Zhonghe Pang left the Isotope Hydrology Section in April 2005 to return to his position in China.

Ms. Laurence Gourcy left the IAEA at the end of May 2005 returning to France where she will begin a new position at the French Geological Survey.

Section Staff bag Agency Awards

A team from the Isotope Hydrology Section, Pradeep Aggarwal, Kshitij M. Kulkarni and Zhonghe Pang, received a team award for "Best Public Information Pamphlet 2003" for the Water and Environment Newsletter, Issue No. 17.

Cheikh Gaye, received an IAEA Merit Award in June 2005 based on exceptional performance.

Meetings

An IAEA advanced course on the use of Isotope Techniques in Water Resource Management" was held at Argonne Laboratories in the USA in April 2005. The course with over 25 participants from several African countries, is part of efforts supported by the IAEA via Technical Cooperation projects for addressing country specific water resource management issues.

In April 2005, the IAEA hosted a preparatory meeting for an initiative to establish a World Commission on Groundwater. The initiative is being led by the World Bank with the International Association of Hydrogeologists, in partnership with the IAEA as well as FAO, UNESCO and other UN organizations.

From 13-15 June 2005 a consultant's meeting was held at the Agency with the objective of developing educational products (training materials and tools) needed to support capacity-building activities in Isotope Hydrology. Based on the meeting results, priority activities will be undertaken by the IAEA Water Resources Programme to meet the identified needs.

In July, 2005 a new Isotope Hydrology module was launched, with the support of the IAEA, at the University of Hanoi, in Vietnam. This is part of the IAEA's efforts to integrate Isotope Hydrology into higher education in Member States.

IAEA Water Resource Activities in the Press

A recent article in the New York Times (July 26, 2005) entitled "With a Push from the UN, Water Reveals Its Secrets" highlights water resource management activities of the IAEA. The article can be accessed at the IAEA web site at: http://www.iaea.org/NewsCenter/News/2005/waterresources.html

IAEA- UNESCO Cooperation

The 2005-2006 workplan for the IAEA-UNESCO Joint International Isotopes in Hydrology Programme (JIIHP) was finalized in January 2005. Along with IAEA support to the WHYMAP initiative (see article on page 16) the IAEA also facilitated expert input into recent UNESCO workshop on Managing Aquifer Recharge held in Lahore, Pakistan, April 2005 as well as worked in the frame of a UNESCO G Wadi programme meeting (July, 2005), to develop improved availability and access to chemical and isotope tracer information of particular relevance to arid zones.

Ode to Isotope Hydrology

I ntense efforts world over on a mystery
S tudies on water dynamics and history
O rigin, age, pathway riddles to solve
T erms of water cycle signs to evolve
O xygen, hydrogen are elements of water
P lurality of atoms mass does matter
E nabling imprints of signals to seek

H eavy hydrogen and oxygen are not freak
Y et demanding to monitor and measure
D azzling equipment of mass spec for sure
R eveals inherent features of test samples
O vert proof of source of those samples
L earning the science of water to manage
O ptimal exploits sans major damage
G round and surface water, aquifers all glitter
Y ield to sound science to be managed better

Natesan Ramamoorthy

Editor's Note

To receive a free copy of Water & Environment News regularly, please write to:
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Alternatively it is also available on the website
http://www.iaea.org/water
Contributions to the newsletter are welcome.

The IAEA Water Resources Programme and the UNEP–GEMS / Water Programme: A Growing Partnership

The IAEA hosted the UNEP– GEMS/Water Technical Advisory Group Meeting in May 2005 reflecting a growing partnership. The IAEA is providing scientific skills, technical information and quality control, and the UNEP provides the management framework for best use: a natural fit and a win-win situation.

Overview

The IAEA's Water Resources Programme is increasingly cooperating with the UNEP on freshwater issues. The Agency is working with the UNEP's Global Environmental Monitoring System/Water (GEMS/Water) Programme on water quality assessment, and also cooperates on shared aquifer management projects funded by the Global Environment Facility (GEF) and implemented by the UNEP.

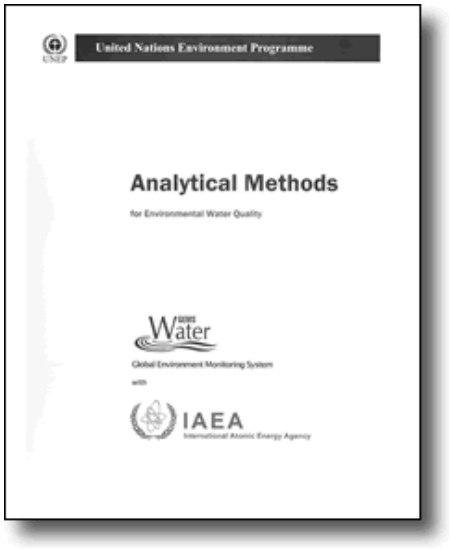
Objective of the Cooperation

The Water Resources Programme (WRP) views the cooperation as an opportunity to enhance the use of isotopic tools while cooperating with other organizations, like UNEP, that support other activities, non-nuclear technologies and capabilities.

Water quality parameters and the capacity to monitor them are essential for successfully using isotope techniques in water resource management. However, the IAEA management and Member States have increasingly indicated that the use of the Agency's funds for non-nuclear technologies should be limited as far as is feasible. Therefore, such cooperation, like the IAEA-UNEP GEMS/Water partnership, is important.

Cooperation with the GEMS/Water programme presents an opportunity to meet the IAEA's objectives of supporting Member States' ability to use isotope and nuclear technologies in the water sector. At the same time Member States' needs for improvements in their capacity for chemical analysis of water can in part be addressed through this cooperation.

In the field of aquifer management, cooperation with UNEP assures integration of isotope techniques in the water sector and enables Member States to link their Technical Cooperation projects to national and regional efforts in improved water resource management.



Jointly published by UNEP/GEMS Water and IAEA Water Resources Programme in 2004

Current Activities

- GEMS/Water and IAEA jointly published the "Analytical Methods for Environmental Water Quality" last year.This includes various methods for chemical analysis and sampling methods for isotopes in hydrological studies. The book, targeted towards capacity building, is expected to be useful for practitioners in the Member States.
- The Agency's Isotope Hydrology Section and UNEP's GEMS/Water Programme collaborate in conducting laboratory inter-comparison testing to ensure accurate and precise measurement of water quality for chemical analyses. This collaboration has helped in avoiding duplication of effort, developing the partnership, and expanding the networks of laboratories in the developing member states.
- The Agency is a member of the Steering Committee of GEMS/Water Programme.

IAEA Deputy Director General, Werner Burkart and Pradeep Aggarwal, Manager of IAEA Water Resources Programme, opening the UNEP GEMS/Water Technical Advisory Group Meeting at IAEA Headquarters in Vienna, Austria, May 2005

- The Agency hosted the 2nd Technical Advisory Group Meeting of GEMS/Water at Agency Headquarters from 2-4 May 2005. The meeting was attended by representatives from the World Bank, FAO, UNEP, IAEA, GEMS/Water Japan, Iraq, South Africa, Germany, UK, the Netherlands, Belgium, Zimbabwe, etc.
- The Agency also hosted, at Agency Headquarters from 4-6 May 2005, a GEMS/Water workshop to develop groundwater quality indicators to be used in the United Nations second World Water Development Report, expected to be published in 2006.

Possibilities for Expansion

Given the IAEA's strong technical base on the ground and its network of partners in Member States as well as UNEP's recognition as the leader in the UN system for natural resource management issues like water, the partnership is a natural fit. Now that there is a good basis for providing data, quality control etc. into UNEP's global network, the next step might be to work to expand the IAEA-UNEP cooperation in the field of water resource management.

This could take the form of joint capacity-building activities and training for water quality monitoring and would be a contribution towards achieving the Millennium Development Goals.

One certain area of growth is further cooperation on projects to manage shared aquifers. The IAEA is already cooperating with UNEP (via TC projects) on the North-Western Sahara Aquifer Project (Tunisia, Algeria and Libya) and the Iullemeden Aquifer Project (Niger, Nigeria and Mali); both co-funded by the Global Environment Facility. Thus there is a good basis for the IAEA and UNEP to enhance cooperation on transboundary aquifers as new projects are formulated.

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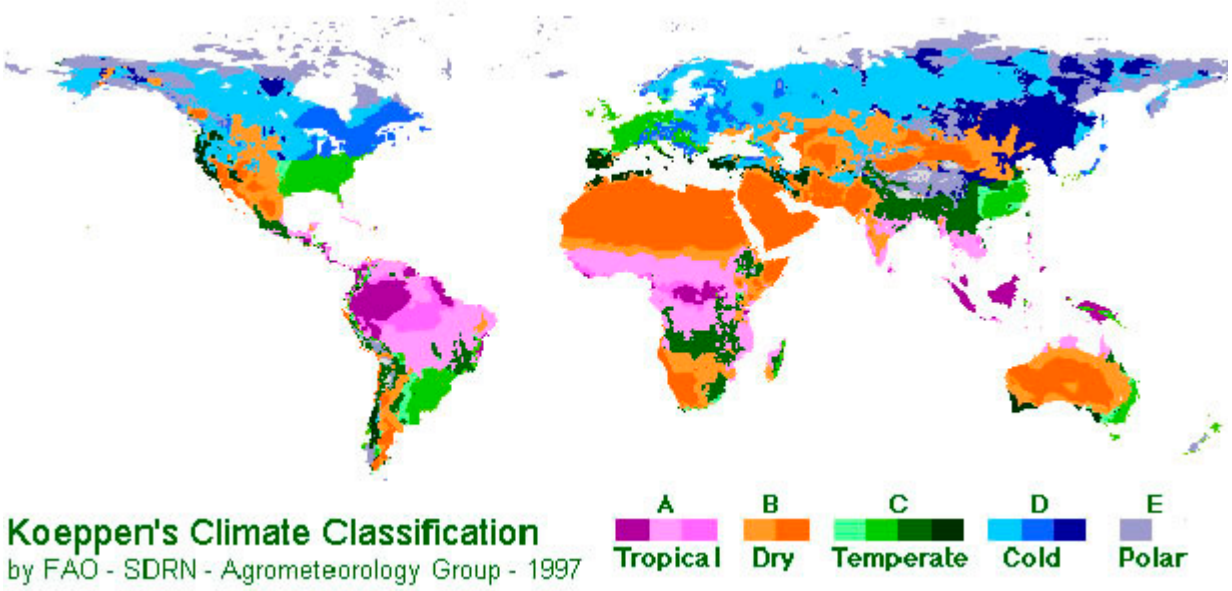
To read a recent IAEA web story on this topic go to http://www.iaea.org/NewsCenter/News/2005/protectwater.html

Isotope tracers in arid zone hydrology: where to now?

The looming world water crisis will be felt hardest in the world's fragile arid zones, where water resources are scarce or non-existent, and groundwater resources are being depleted at ever increasing rates.



The warm arid zones cover large areas of the Earth in the low to mid latitudes. Rainfall is generally low and variable, with inter-annual variability ranging over a factor of 5-10.

Information provided by isotopic tracers has revealed a number of stark realities:

- Many fresh groundwater resources in arid zones are palaeowaters and implicitly non-renewable,
- Recharge rate are currently very low, and often of poor quality,
- Interactions between surface waters and groundwater are such that diverting or pumping of one invariably has an impact on the other.

None of this is what water users and managers want to hear.

The application of environmental tracers to arid zone hydrology over the past 30 years has added enormously to our understanding of recharge processes and subsurface water fluxes in dry parts of the world. Because water fluxes are so low, environmental tracers provide unique and quantitative data that is spatially and temporally integrated.

In a world where there is little scope for more diversion of surface waters for new resources, putting further pressure on meagre groundwater supplies requires a concomitant investment in improving knowledge of water fluxes and impacts on ecosystems that depend on it.

New developments in technical capability, the emergence of eco-hydrology, and the demand for more technically robust and quantitative outputs has driven the expansion of isotope hydrology throughout the world. But arid zone isotope hydrology – which can potentially be applied to many arid zone problems – still faces a number of scientific and practical questions:

Linkages between the atmosphere-soil-water-vegetation continuum, although qualitatively understood, elude quantitative transfer to a scale commensurate with basin scale groundwater management. Improved and more robust technological development, and widespread availability of these approaches, will be invaluable in advancing the science and its application to solve water resource issues.

Tracer information

Much of the tracer information is imparted or modified at key interface zones:

i) The upper 5 m of the soil zone,

ii) The capillary zone, and

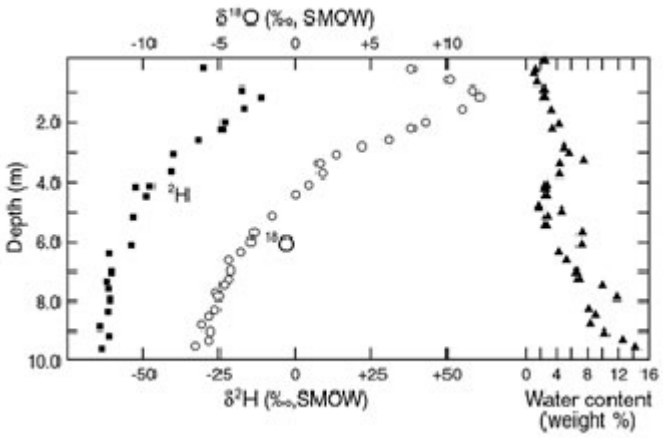
iii) The discharge zone .

These zones are characterised by large gradients in water content, salinity and oxygen levels: further work is warranted in these zones. The burgeoning field of eco-hydrology will depend on better characterisation of processes in these zones.

Recharge/discharge dynamics

Systematic comparisons of data sets from different parts of the world could improve the understanding of the overall factors controlling recharge and discharge. This may not necessarily lead to a comprehensive "unifying" paradigm (which is unlikely in such complex systems) but could provide proxy, widely available datasets that are amenable to scaling up to regional dimensions that are useful for water managers.

Evaluating whether there are particular thresholds or non-linearities in response to forcing functions (such as rainfall amount, vegetation density, elevation gradients, etc.) will also be necessary if there are to be simple models that relate current short-term observational records (e.g. rainfall amount) to long-term groundwater flow systems and recharge rates, which function on the scale of centuries to millennia.



Soil water stable isotope profiles in the Sahara that are used to estimate discharge rates. (Fontes, J.-Ch., Yousfi, M. and Allison, G.B., J. Hydrol., 86, 315-327, 1986).

Managed Aquifer Recharge (MAR)

The increasing need for reliable water supplies in arid and semi-arid countries has seen a massive upsurge in the interest in managed aquifer recharge, formerly referred to as artificial recharge.

The development of such projects generates the need for technologies to be adapted to make possible improved design and management.

Isotopic data provides information about movement, mixing and biogeochemical processes of injected water. The IAEA is facilitating increased application of these tools, in the Middle East and Latin America through training courses, regional and national Technical Cooperation projects and the engagement of experts.

Further development of a programme is anticipated with the aim of defining how isotopic tools can be more effectively used to characterize site suitability, and to monitor mixing and flow systems in a variety of hydrogeological settings.

The potential of the techniques is well known; the next phase is to develop a set of easily adaptable tools to suit site-specific requirements.

From study sites to whole basins

Studies are needed at a range of intermediate spatial scales to link water management agencies' basin scale studies (borehole and well sampling programs) with research agencies' very fine, detailed studies testing specific process models (detailed soil profiles). Very rarely are systematic field programmes undertaken designed to link processes from the point study through to the whole basin.

Geological challenges

Much of the world's arid zones are underlain by fractured rock aquifers, and compared with porous media very little research has been carried out on these. The main reason that they have been avoided is because research in these areas is perceived as too difficult, but tracer techniques may provide the best avenue for success.

For example, fractured rocks have very low porosity, but high hydraulic conductivity in a small fraction of the bulk aquifer. In these systems, sampling in different ways can give conflicting results (e.g. diffusion cells; piezometers; pump-packers in open boreholes). There is a need to

Despite the harsh climate, many desert areas support a robust and diverse plant, animal and insect communities. This photograph from Central Australia shows that large trees and shallow-rooted grasses can survive using soil water and shallow groundwater recharged during intermittent heavy rainstorms and floods.

resolve these practical issues if we are to be able to interpret the data properly.

Environmental isotopes continue to have much to offer in helping to solve the practical problems of arid zones. Spatial analysis tools present opportunities for isotope tracers to be integrated into management tools for the sustainability of water resources and environments in the fragile arid zone.

IAEA continues to foster the transfer of knowledge of new techniques and methodologies through training, CRPs and Technical Cooperation projects.

Footnote: This article is partially a distillation of the outcomes of a mini-symposium held in Adelaide in December 2000, and presented at the Symposium on 'Isotopes in the Hydrological Cycle and Environment' held at UNESCO, Paris in September 2004 in honour of Jean-Charles Fontes, 10 years after his death. The input and feedback from all contributors and participants is gratefully acknowledged.

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Workshop on Groundwater Governance and Management in Arid and Semi-Arid Climates Cairo, Egypt April 3-8, 2005

This event - sponsored by WMO and co-sponsored by the IAEA, UNEP and UNESCO, brought together some 70 people from various disciplines involved in groundwater management in arid and semi-arid zones.

The intention was to enhance communication among the Hydrological, Economic, Social Science and Legal fraternities to increase the capacity of developing countries in sustainable groundwater use. While information and knowledge sharing is well established within each discipline, transfer to policy and management practices are not as advanced as might be expected or desired.

The emphasis of the workshop was on case studies from countries with predominantly arid and semi-arid climates, and the inherent problems in managing exploitation of renewable and non-renewable aquifers. The workshop highlighted the need to make better use of information transfer to both the political and grass roots levels.

Isotope hydrology can play a key role by providing unique information about the extent of the resource, and about the responses (and their time-scales) of groundwater – both in terms of amount and quality – in response to exploitation.

The IAEA will publish the proceedings in late 2005.

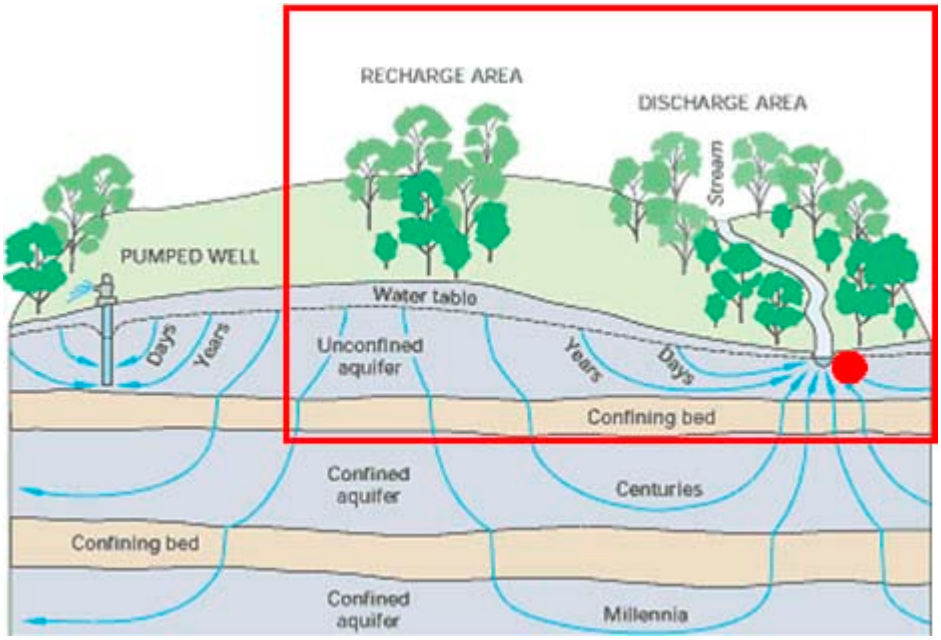
Isotopic Age and Composition of Streamflow as Indicators of Groundwater Sustainability

Understanding the interaction of surface water and groundwater in river basins is essential to water managers and scientists alike.

Management of just one component, such as a stream or an aquifer, is often only partly effective, because each component of the water cycle is in continuous interaction with the other components.

a new Coordinated Research Project entitled "Isotopic Age and Composition of Streamflow as Indicators of Groundwater Sustainability" has been launched by the IAEA; the first Research Coordination Meeting was held in November 2004.

The goal is to develop new isotopic methodologies and



General concept of the river/aquifer interface in time and space (background picture © USGS)

For example, water in streams has two main components: surface runoff in response to rain or snowmelt, and base flow, which is water that recharges as precipitation to shallow aquifers. Base flow moves along flow paths of varying lengths and enters the river after varying subsurface residence time through streambeds (see diagram, above). Streams that are supplied by a large proportion of base flow tend to have relatively low temporal flow variability, which makes them more reliable sources for water resource purposes.

The role of isotopes

Isotopes in stream flow are excellent environmental tracers, which can help estimate the proportion, origin and subsurface residence time (age) of the baseflow. Therefore indicators of baseflow for sustainable management of the interface stream/aquifer in river basins.

Sixteen research groups are participating, and the workplans of the groups in the first project year focus on the compilation of existing hydrological and hydrogeological data and setting up appropriate field sampling plans for isotopes of water (^{18}O, ^{2}H, ^{3}H) and of dissolved gases (CFC, ^{3}He).

The Agency also provides, in collaboration with the University of Utah, testing of new equipment of sampling of noble gases in water, and will be supporting the CRP with analytical facilities for ^{3}He.

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A global network for sampling moisture isotopes in the biosphere and atmosphere (IAEA-MIBA)

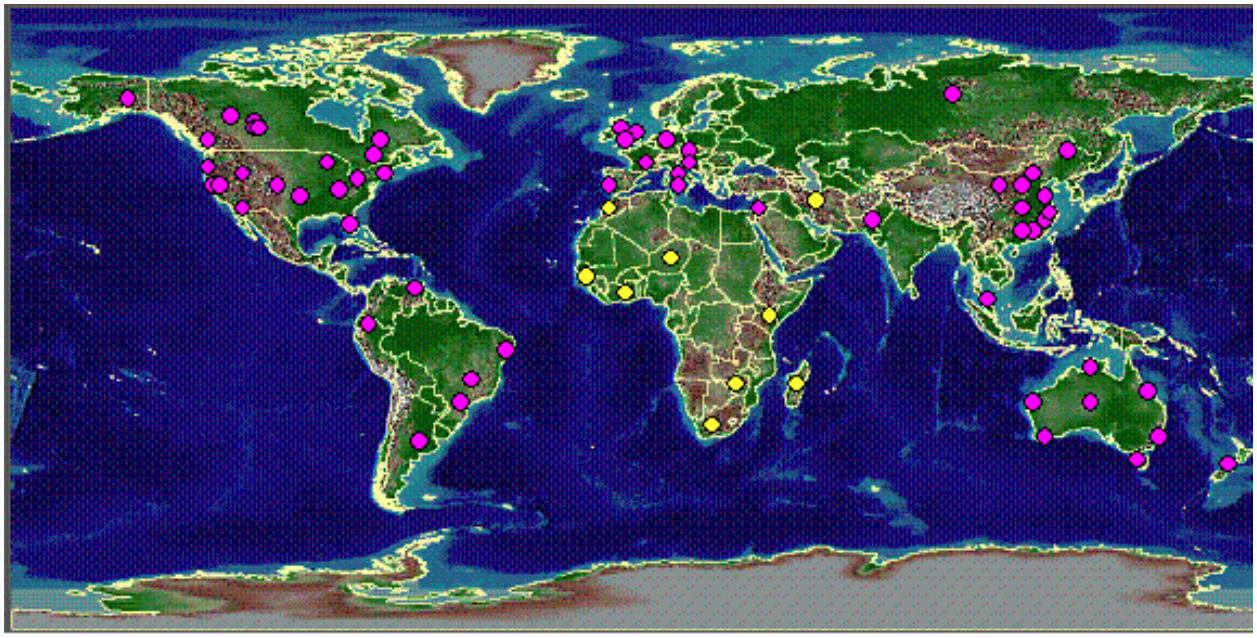
A new CRP, launched in 2005, by the IAEA Water Resources Programme, is an initiative to establish a network to monitor the isotope composition of moisture in plants , soils and air; important data needed to model global environmental changes.

Background and justification

Experimental data on stable isotopes in biospheric and atmospheric moisture is scarce. But routine measurements of stable oxygen and hydrogen isotopes are crucial to the advancement of hydrological and climate research at the ecosystem, regional and global scales.

The International Atomic Energy Agency (IAEA) has therefore set up the IAEA Moisture Isotopes in the Biosphere and Atmosphere (IAEA-MIBA) Group. It includes a group of scientists with diverse research interests ranging from the ecosystem to global scales.

The IAEA has long operated the Global Network of Isotopes in Precipitation (GNIP), which has provided global data to understand and simulate the water cycle under present and past climates. The establishment of the IAEA-MIBA Group supports our efforts to improve the availability of isotope data for other water cycle components in an effort to supplement GNIP data and integrate isotope applications in hydrological cycle, carbon cycle and climate research.



Current site distribution of the IAEA-MIBA network. Pink dots are sites which are currently online which means that we have the capacity to collect, extract and analyze all samples. Yellow sites should be online within a year.

Going beyond the models

The IAEA-MIBA Group's work will help provide an alternative to our present dependency on model outputs for some key variables, and further advance our understanding of:

- Regional scale hydrological budgets: partitioning evapotranspiration fluxes into surface evaporation and vegetation transpiration; distinguishing evapo-transpiration vs advection; quantifying local and regional water recycling; improving closure of continental, regional and watershed isotope mass balance.

- The partitioning of annual carbon fluxes. The measured variables in the MIBA network drive the ^{18}O composition of atmospheric CO_2. The measurement of ^{18}O in CO_2 offers both an additional constraint and smaller uncertainties for CO_2 flux partitioning between the ocean and the terrestrial biosphere at the global scale; and between assimilation and respiration in land ecosystems.

- The development of new global change indicators. ^{18}O and ^{2}H in atmospheric vapour can be used as indicators for regional to global-scale reductions in evaporation perhaps in response to changes in global dimming and brightening.

- Ecosystem functioning. distinguishing productivity responses due to soil moisture stress vs. atmospheric humidity stress; ecosystem-specific effects on the ^{18}O of atmospheric CO_2; ecosystem-specific patterns of water use (meltwater, permafrost), and allowing the combined use of oxygen and carbon isotopes.

- Interpretations of ^{13}H and ^{18}O analyses in organic matter: Improvement of tree ring based climate reconstructions; explaining the cause of genetic variation in C_i/C_a(net photosynthesis vs. stomatal conductance).

- The validation of general circulation models, particularly those weather prediction models that aim to couple carbon and water fluxes using stable isotopes to improve simulations of the water and carbon cycles.

- Past global responses to climate change. Biospheric productivity forces a difference between the oxygen isotopes of ocean water and atmospheric O_2(the Dole effect). The measurements from the MIBA network will allow further elucidation of the current Dole effect, and allow us to constrain estimates of past global productivity using H_2O and O_2 trapped in ice cores.

Initial meetings and current state of the network

The initial consultants' meetings of November, 2003 and May, 2004 resulted in the development of the basic network design and sampling concepts. It was determined that regular sampling of the isotopic composition of water in plant leaves, stems, soil and atmospheric vapour would help achieve considerable benefits to the research community.

The general framework of the network is as follows:

- Regional representatives recruit field sites in broadly defined global regions to sample leaves, stems and soils. These sites will then send the samples to extraction and analysis labs

- The IAEA's isotope laboratory (and those of several group members) will provide isotopic analyses for participants who do not have the availability or capacity to perform the required analysis.

- The IAEA will provide the secretariat for the work of the MIBA Group and may provide modest financial support for facilitating sampling, particularly in developing countries. The Group will also assist in providing training and logistics according to needs.

- Results of all analysis will be immediately made available in an IAEA web page to all participants who will be given priority in any public dissemination of data.

- Products of this network will lead to periodic meetings (organized by the IAEA) where participants will be invited to discuss results of their efforts.

Building the network

On June 1, 2004, the arrangements for establishing the regional representatives and sampling sites started, with the aim of implementing the sampling program in April/ May, 2005.

The regional representatives and representatives from the central analysis labs met in Vienna on May 2-4, 2005 to discuss the results of the recruitment effort, analysis capacity and sampling protocols in an effort to assess the current state of the network and to decide on the future directions of the networks. The participants gave summaries and vegetation descriptions of sites within their regions that have successfully been involved in the network.

Details of extraction and analysis capabilities per year were presented along with the current timeline for collection of samples at these sites. Current sampling and analytical capacity of the MIBA network was established with approximately 58 sites worldwide and 9 more sites projected within a year (see Figure on page 14).

For a complete summary of the MIBA network, please visit the new website at www.iaea.org/water or contact: L.Araguas@iaea.org.

Mapping Global Recharge

The IAEA is leading an activity that is trying to estimate the level of groundwater recharge at a global level as part of a UNESCO led WHYMAP initiative.

Contributing to the hydrological map of the World (WHYMAP)

Current estimates of the worlds' water resources are generally weak as regards groundwater (GW) components and no information is available as to what proportions of the groundwater bodies are renewable or non-renewable.

The development of the Agency's GIS mapping of water resources from around the world is a very important contribution to efforts on the development of the Hydrogeological Map of the World (WHYMAP, 1:25,000,000). These efforts are made in collaboration with the Commission for Hydrogeological Maps in cooperation with UNESCO and the International Association of Hydrogeologists (IAH).

A Consultant Meeting was held at IAEA in January 2005 to review the current status of global GW recharge. The purpose of that meeting was to discuss and identify new data (isotopes) to be compiled and used for estimates of global GW recharge. Completion of this task will provide two new map layers to the WHYMAP, i) Global groundwater recharge estimates, and ii) overview of non-renewable groundwater resources. Both of which will be important contributions to groundwater management efforts.

The consultants advised on how to improve estimates of global GW recharge and on potential methodologies for integrating the data into the WHYMAP.

Next Steps

Key challenges in creating a world-wide picture of GW recharge will be to:

a) Find and compile new independent ("observed") information on groundwater recharge (chloride/ isotopes)

b) Integrate isotope data information into WHYMAP (e.g. on confined/unconfined conditions)

c) Improve the modelling of groundwater recharge and total runoff.

The meeting agreed that the recharge map would be an essential component of WHYMAP, thus helping to assess the sustainability of groundwater resources for human and ecosystem needs. Efforts will continue during the rest of 2005 and early 2006 to enhance the map layers as well as to identify further steps for improvement. It is also planned to present the results at the upcoming 4th World Water Forum, Mexico 2006 where groundwater management will be a central theme.

For further information please contact:
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Meetings held in 2005

- Technical Meeting on groundwater recharge, Vienna, 10 - 13 January 2005
- Meeting on the Preparation of a GEF Medium-Sized Project Proposal for an International Groundwater Commission and Forum, Vienna, 28 - 30 April 2005
- Research Coordination Meeting on isotope methods for the study of water and carbon cycle dynamics in the atmosphere and biosphere, Vienna, 2 - 4 May 2005
- GEMS/Water Technical Advisory Group meeting, Vienna, 2 - 4 May 2005
- Technical Meeting on Preparation of a Tritium/^{3}He Guidebook, Vienna, May 2005
- Consultants Meeting to evolve a strategy to develop easy to use training materials to support capacity building in isotope hydrology, Vienna, 13 - 15 June 2005
- Consultants Meeting advice on developing a brief for application of isotopes in managed aquifers, Vienna, 16 - 18 June 2005
- Consultants Meeting to review the drafted version and final editing of the French version of the UNESCO/IAEA books on isotope hydrology, Vienna, 14 - 17 June 2005

Forthcoming meetings in 2005

- Consultants Meeting on Isotope Techniques for Understanding the Water Quality Impacts of Wetlands, 17-20 October 2005, Vienna.
- Consultants Meeting on the 'Use of isotopes in the assessment of river-aquifer interactions: A case study of the tri-country Austrian-Slovak-Hungarian part of the Danube basin' 24 - 25 October 2005, Vienna.
- Consultants Meeting on 'Guidelines for the use of Compound Specific Isotope Analysis (CSIA) in bioremediation', 27 - 28 October 2005, Vienna.
- Consultants Meeting to 'Review operational aspects of the IAEA-WMO Global Network of Isotopes in Precipitation', 7 - 9 November 2005, Vienna.
- Consultants Meeting on the 'Fourth meeting of the Scientific Steering Committee of Global Network of Isotopes in Precipitation (GNIP)', 10 - 11 November 2005, Vienna.
- Third Research Coordination Meeting on the CRP on 'Design criteria for a network to monitor isotope compositions of runoff in large rivers', 28 November - 2 December 2005, Vienna.
- Final Research Coordination Meeting on the application of isotopes to the assessment of pollutant behaviour in the unsaturated zone for groundwater protection, 21 - 25 November 2005, Vienna.
- Final Research Coordination Meeting on the development of nuclear and isotopic techniques for characterization of Submarine Groundwater Discharge, 13 - 16 December 2005, Vienna.

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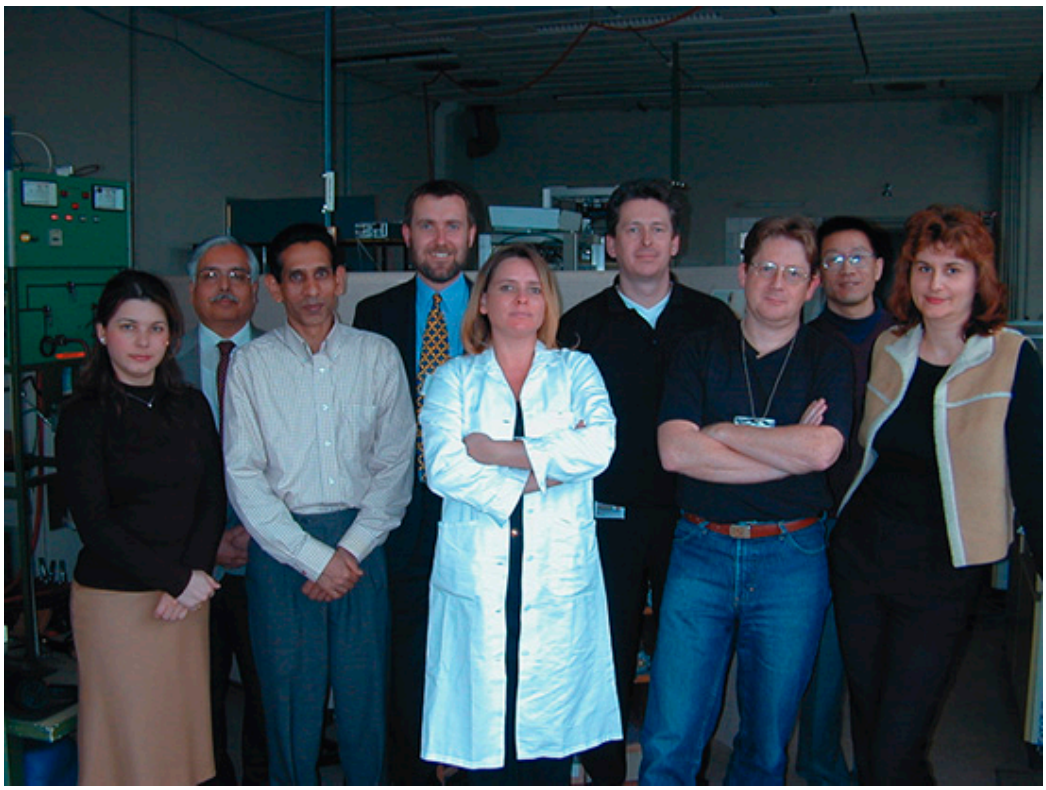


Staff members of the Isotope Hydrology Laboratory

front row: Ms. Andreescu, Liliana; Mr. Sambandan, Chinmaya; Ms. Brummer, Daniela; Mr Van Duren, Michael; Ms Dargie, Marina; Back row: Mr. Tanweer, Ahmad; Mr. Groening, Manfred; Mr. Jacklitsch, Manfred; Mr. Han, Lieng-Feng

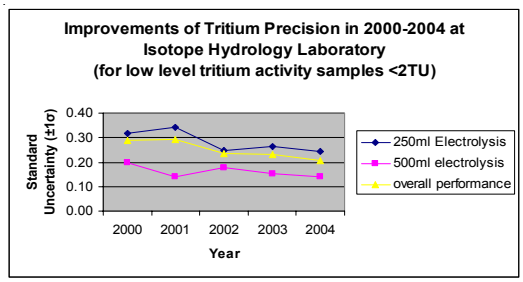
In Isotope Hydrology Laboratory

Laboratory extension: The planned extension of the IHL by 200 m^2 additional laboratory and office space will be realized in autumn 2005. It will improve existing facilitiesfor tritium enrichment and for reference material handling. At the same time a new stable isotope mass spectrometer will be installed for water analysis using high temperature water pyrolysis and continuous flow techniques.

^{3}H/^{3}He laboratory: The construction of the extended sample inlet system started, combining advanced features reducing any ^{3}He background (use of stainless steel sample containers - University of Utah, attaching samples by a cutting flange techniques - ETH Zurich, including the possibility for pre-analysis of heavy noble gases). The design of a 10 port sample extraction system for cupper tubes is completed.

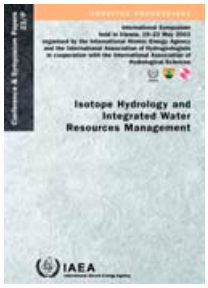
External accreditation audit: A formal accreditation audit was performed recently in a Latin American isotope hydrology laboratory with staff of the isotope hydrology laboratory acting as a technical auditor and checking methods for compliance with ISO17025 used for analysis of tritium in water, $\delta\ ^2H$ in water and $\delta\ ^{13}C$ in organic matter.

Precision of tritium analyses: The precision of routine tritium analyses was considerably improved during the last four years. A recent compilation verified a significant improvement for low-level samples (<2TU) with an improvement in yearly average measurement precision using the 250 mL electrolysis from ±0.3TU to ±0.25TU and for the 500 mL electrolysis from ±0.2TU to ±0.15TU (see diagram, below). This was achieved to a large extent through changes in the routine measurement process optimising the tritium background measurements.



Sales of Reference materials: The 2004 sales statistics for stable isotope reference materials showed the highest value ever with 740 units sold. At the same time about twenty new reference and quality control materials were included in the IAEA AQCS catalogue. http://www.iaea.org/programmes/aqcs

Recent Publications



Isotope Hydrology and Integrated Water Resources Management

C&S Papers Series No. 23

Global effects to overcome the growing challenge of freshwater availability have been at the forefront of the world development agenda for nearly three decades. For developing policies towards sustainable management of freshwater resources, an improved understanding of the Earth's water cycle bas been widely recognized as one of the key elements of scientific information. The IAEA has played a crucial role in promoting and expanding the field of isotope hydrology. Starting in 1963, the IAEA's quadrennial symposia on isotope hydrology have played a central role in developing this scientific discipline. This publication contains 174 extended abstracts of papers presented during 11 technical sessions of the 11th symposium in the series that was convened during 19-23 May 2003 in Vienna. Nearly 275 participants from 69 countries participated in the symposium to discuss the past, present and future of isotope applications in hydrology and climate research. The proceedings is available on CD-ROM and in print.

IAEA-CSP-23/P, 2004, ISBN 92-0-108604-0, English, 15 Euro

IAEA-CSP-23/CD, 2004, ISBN 92-0-114204-8, English, CD-ROM, 15 Euro

Guidebook on the Use of Chlorofluorocarbons in Hydrology: 2004 Edition

Technical Reports Series No. 438

The Guidebook on the use of chlorofluorocarbons (CFCs) in hydrology provides a comprehensive overview on this available methodology to detect young groundwater components and to determine groundwater residence times. It provides an extensive introduction to the scientific basis, including discussion of existing complications as contamination or degradation effects. Numerous case studies are presented and discussed. It guides to a proper interpretation of data, puts the CFC method in the context of other existing methods and discusses in detail CFC field sampling and analytical methods. Several computer programs are provided on the attached CD which aim to facilitate the interpretation of CFC data and their comparison with results based on conceptional water flow models.

STI/DOC/010/438, ISBN 92-0-100805-8, English. 52 Euro

Isotopic Composition of Precipitation in the Mediterranean Basin in Relation to Air Circulation Patterns and Climate

IAEA TECDOC Series No. 1453

The present publication is a compilation of the results obtained under the Coordinated Research Programme (CRP) "Isotopic Composition of Precipitation in the Mediterranean Basin in Relation to Air Circulation Patterns and Climate" from 2000 to 2004. The isotopic composition of precipitation is closely connected with the rain formation conditions, i.e. with the temperature of formation, the origin of the air masses, and the degree and mechanism of rainout. Stable isotopes are, therefore, powerful tools for investigating the precipitation and formation conditions, and for monitoring their changes in parallel to the observed climatic changes. The CRP included the participation of 14 countries: Algeria, Austria, Croatia, Egypt, France, Greece, Israel, Italy, Lebanon, Morocco, Portugal, Slovenia, Spain and Turkey. Hydrologists, hydrogeologists and meteorologists were involved in the project and collaborated at the national and regional levels. This was essential for the real integration of isotopes into climate studies.

IAEA-TECDOC-1453, , ISBN 92-0-105305-3, English, 15 Euro

Use of Isotope Techniques to Trace the Origin of Acidic Fluids in Geothermal Systems

IAEA TECDOC Series No. 1448

Acidic fluids occur in geothermal well discharges. As they cause serious damage to production wells and transmission pipelines, their origin needs to be understood in order to design appropriate preventive or treatment measures for sustainable geothermal energy production. Realizing the potential contribution of stable isotopes of the water molecule and those of sulphur compounds in tracing the sources of acidic fluids, especially the sulphate type of acidity in geothermal well discharges, the IAEA implemented a Coordinated Research Project (CRP) in which ten research groups carried out field and laboratory investigations on twenty geothermal fields. Scientists in this project used a variety of isotopes as tracers and temperature indicators for geothermal systems. They following major results were obtained: (1) identification of the origin of the water component in acidic fluids, (2) identification of the origin of sulphur compounds in acidic fluids, (3) mixing relations between waters from different sources to form acidic fluids and (4) a test of isotope geothermometry based on sulphur compounds in geothermal fluids. This publication is a compilation of the final reports of the research project with a summary of the findings.

IAEA-TECDOC-1448, 2005, ISBN 92-0-102805-9, English, 15 Euro

Isotope Hydrology - Learning, Teaching and Applying Isotope Techniques in Hydrology

IAEA-IHLS, 2004, English, CD-ROM. Unpriced.This new CD has been produced to support the teaching of Isotope Hydrology for postgraduate students as well as for water resource professionals. It includes the six volume set of the IAEA/UNESCO textbook series "Environmental Isotopes in Hydrological Cycle"; Graphical solutions to selected equations in the textbooks; Geochemical modelling software: NETPATH, SOLMINEQ and transport models.

IAEA International Atomic Energy Agency

Water and Environment News No. 19 September 2005

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