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Water & Environment News

Newsletter of the Isotope Hydrology Section
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In this Issue

IAEA Water Resources Programme

IAEA General Director Yukiya Amano and US Secretary of Energy Steven Chu taste water of different ages at the 2011 Scientific Forum.

From the Section Head

As a part of the IAEA Director General's thematic focus on water during 2011, a Scientific Forum on water was convened during the annual IAEA General Conference. The Forum provided insights into the world's water problems and highlighted the role that nuclear techniques can play in key issues. The US Secretary of Energy and Nobel prize winner Steven Chu illustrated how isotope hydrology is a valuable tool to manage water resources and understand climate change. We have posted a video of key presentations, including that of IAEA Director General Amano and Dr. Chu, on our website (www.iaea.org/water).

Besides the Scientific Forum, this edition of the newsletter focuses on improving the quality of isotope measurements. The IAEA has been conducting periodic comparisons of analysis of blind samples by laboratories worldwide for over 40 years. In the area of stable isotopes, an inter-laboratory comparison was held with double the number of participating laboratories compared to the last exercise in 2002. There was also increased interest in the application of environmental isotopes in other disciplines where tracing the origin of water is useful. Increases both in the number of laboratories and areas of application are mainly due to the revolution brought about by relatively easy to use and lower cost laser spectroscopic analysis techniques. The IAEA has played a significant role in facilitating the widespread use of laser machines during the testing and adaptation phases and now through the provision of these machines to nearly forty Member States. We are now undertaking a design modification of the laboratory tritium enrichment system so that the use of tritium as a hydrologic tracer may be exploited to its fullest extent by scientists worldwide.

P. Aggarwal

Scientific Forum Addresses International Water Problems and Searches for Solutions

From detailing the looming global water crisis to discussing the individual problems facing Member States and exchanging information about how to mitigate these problems, the Scientific Forum provided a platform for scientists and water experts.

Callist Tindimugaya, Senior Water Resources Specialist from Uganda, speaks at the Scientific Forum isotope hydrology session (photo: IAEA).

The importance of water on the international agenda will continue to grow as water shortages and competition for water becomes greater around the world; the International Atomic Energy Agency Scientific Forum 'Why Water Matters — Making a Difference with Nuclear Techniques' highlighted the role that nuclear techniques can play in solving key water issues.

From a moving speech by US Secretary of Energy and Nobel prize winner Steven Chu, to lively discussions and the chance to blind taste water of different ages, the Scientific Forum, held 20–21 September 2011 in Vienna, provided insights into the world's water problems, while top experts offered solutions and water managers were offered a chance to exchange information.

IAEA Director General Yukiya Amano opened the Scientific Forum on 20 September, stating that although the water aspect of the IAEA's work does not receive the same attention as nuclear safeguards, safety and security, it is just as important and of great value to those countries which benefit. "There is virtually no area of human activity that does not depend on water. It is vital for human health, for agriculture, for industrial development," he stated.

However, many parts of the world suffer serious issues around water, from shortages to flood to contamination, and the problem is expected to get worse. "For over half a century, the IAEA has been employing its unique experience in using nuclear techniques to understand and manage water. In more than 90 countries, our experts meet with national counterparts to find, manage and conserve fresh water supplies and protect our oceans," added Amano.

He went on to add that the Scientific Forum would highlight three key areas of the IAEA's work that are already delivering benefit to Member States, including water resources assessment, water insufficiency in agriculture and protection of the oceans. "Your insights and ideas will be vigorously followed up to help improve the quality of services we offer to Member States, in cooperation with our many partners, national and international, who are represented here today. With the expertise assembled in this room, we will be better able to meet the challenges the world faces in the areas of water and to make a meaningful difference to the lives of many thousands of people."

Steven Chu

Director General Amano's speech was followed by that of Steven Chu, who discussed some of the solutions science has to offer in addressing the greatest challenges of our time and mitigating the impact of man's activities on the planet, including the role isotopes can play in this context.

Chu pointed out that a large part of the world is already suffering from water stress conditions, expressed how need

is growing and how water wars could be a part of our future. Chu added that the USA considers isotope hydrology to be an excellent application of the peaceful uses of nuclear technology and will continue to support the work of the IAEA through its Peaceful Uses Initiative.

"...science can be used to address the greatest challenges of our time," stated Chu, adding that water and its distribution will be intimately tied to both climate change and energy.

"We are changing the destiny of the Earth and it is up to us collectively as the human race to do what we can to mitigate the worst of those risks, and its up to science to help show the way how to do that."

Both speeches can be seen in full on the Water Resources Programme website (http://www.iaea.org/water).

Other speeches were given by Amina Benkhadra (speech delivered by Ambassador of Morocco Omar Zniber), Srikumar Banerjee, Department of Atomic Energy, India and Andrei Bourrouet Vargas, Vice Minister for Energy, Costa Rica. The session closed with a water tasting event in which the prominent speakers at the opening session were invited to sample water of varying ages, up to one million years old.

The isotope hydrology session, aimed at discussing water availability, assessment and management, and held on the afternoon of 20 September, was well attended and featured speakers who not only brought interesting information to the audience, but offered innovative ideas and approaches to water management issues. Speakers included Andras Szöllösi-Nagy, Institute for Higher Education in Water, UNESCO, Matthew Larsen, United States Geological Survey, Yuri Maruo, Japan International Cooperation Agency, Catherine Tovey, The World Bank, John Dodson, Australian Nuclear Science and Technology Organisation, James S. Famiglietti, University of California, USA and Guillermo Q. Tabios III, National Hydraulic Research Center, Philippines.

'...science can be used to address the greatest challenges of our time.'

— Chu

After delivering individual speeches, a panel discussion, hosted by BBC's Naga Munchetty, heard the various guest speakers debate finer points of isotopes and water management. This was followed by a water tasting in which all participants were invited to partake in various water samples and guess which waters were 'old' and which were 'young'.

The Water Resources Programme promotes the use of scientific assessments of aquifers to support nations in their struggle to sustainably use water resources, and encourages cooperation over shared resources between neighbours. The Scientific Forum offered a rare and unique opportunity to engage many stakeholders in the area of water management in debate and the exchange of information.

For further information contact Luis Araguas at L.Araguas@iaea.org

Water tasting after the isotope hydrology afternoon session at the Scientific Forum (photos: IAEA).

Scientific Forum Speakers Tell their Views at the 'Making More Water Available' Session

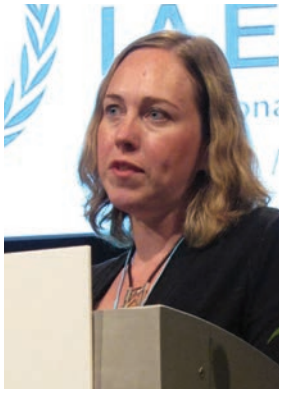
Lively discussion and debate were the order of the day at the isotope hydrology afternoon session. Speakers addressed an interested and engaged audience, and after delivering their speeches had an open forum discussion.

András Szöllösi-Nagy, Rector of UNESCO-IHE Institute for Water Education

András Szöllösi-Nagy spoke about the looming global water crisis, which will lead to serious water struggles within the next few decades. He said water will become one of the most important or the most important issue of the 21st century, and added it connects all human, social and environmental systems. Szöllösi-Nagy said the way out is to build up capacities for water resources assessment, as well as to focus on education and capacity building.

Matthew Larsen, Associate Director for Climate and Land Use Change at the United States Geological Survey, United States of America

The CO_2 data gathered since the 1960s shows an acceleration in the amount of CO_2 in the atmosphere, according to Matthew Larsen. This data alone points out how important it is to invest resources in scientific monitoring, he says. Larsen also mentioned case studies involving isotope hydrology, including one to clearly determine a vexing source of chloride near New York, and one aiding Afghanistan in tying together its water sources.



Catherine Tovey, Senior Water Resources Specialist, The World Bank

Catherine Tovey recapped the serious situation that struck Bangladesh in the mid-1990s when arsenic poisoning became an issue after people started getting sick from water drawn out of the country's shallow aquifers. She discusses how the IAEA played a great role in an international cooperative effort, using isotopes to define the problem and find safe sources of drinking water. Other challenges still face the country today, including bacterial illness and a growing problem with saline intrusion. Tovey is counting on isotopes to help provide insight into these problems to try and secure a safe drinking water supply in the future for everyone in the country.

Callist Tindimugaya, Senior Water Resources Specialist, Directorate of Water Development, Ministry of Water, Land and Environment, Uganda

Uganda faces serious and unique challenges regarding its water resources, and water is the key to poverty alleviation, according to Callist Tindimugaya. He clarified what those problems are, and added the greatest difficulty is that decision makers lack the tools they need to guide them because they do not have enough information about their resources. Isotope hydrology has been successfully used to fill that gap in specific cases, but much more work needs to be done to uncover the mysteries of water resources country-wide.

Yuji Maruo, Senior Advisor, Japan International Cooperation Agency (JICA), Japan

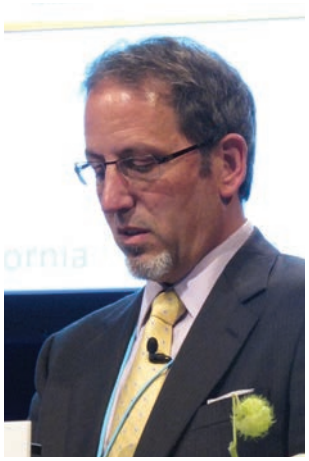
Over the last three decades, Japan has, through JICA, undertaken the provision of much assistance to sub-Saharan African countries. The same two hindrances to water management keep reappearing in the course of JICA's work; limited resources and lack of information, said Yuji Maruo. JICA has attempted to overcome some of the former by implementing training programmes, and hopes to deepen work with the IAEA in order to alleviate the latter. "The IAEA is very much experienced...I hope that the IAEA and JICA will have more chance to work together to make more water available in the future," stated Maruo.

The expansion of high pressure cells due to global warming is going to lead to the expansion of the world's mid-latitude deserts, said John Dodson, leading to greater dependence on groundwater resources. To manage these largely unknown resources, it is important to learn about source and origin, age and replenishment rate of aquifers, and the best tools for this are isotope and geochemical tools, he said. Dodson highlighted good and bad news stories on Australia's future water situation.

John Dodson, Head of the Institute for Environmental Research, Australian Nuclear Science and Technology Organisation (ANSTO), Australia

Guillermo Q. Tabios III, Professor of Civil Engineering; Director, National Hydraulic Research Center, University of the Philippines, Philippines

The Philippines faces many water challenges, not the least of which are the fact that the country has about 40 water basins, many on separate islands, said Guillermo Tabios III, and there are many situations where groundwater is clearly being mined, leading to a host of problems. Perhaps the most significant barrier to better water management is a lack of awareness of water issues and resources being spent; to this end the country hopes that its involvement in the new IAEA Water Availability Enhancement Project (IWAVE) will supply some scientific answers and that models will help to bridge the disconnect between science, technology and policy management.



James S. Famiglietti, Founding Director of the UC Center for Hydrologic Modelling; faculty in Earth System Science and Civil and Environmental Engineering, University of California, Irvine, United States of America

The Gravity Recovery And Climate Experiment (GRACE) has been making detailed measurements of the Earth's gravity field since its launch in March 2002, said James Famiglietti. Minor changes in gravity data can be used to estimate how water storage is changing from place to place around the planet, from measuring melting ice sheets to groundwater depletion. Famiglietti said there is a lack of knowledge about how much water we have under our feet, and if isotope based residence times and groundwater age data can be combined with GRACE data depletion rates, it would be possible to have a really complete description of groundwater availability, greatly contributing to sustainable water resource management.

Members of the audience had a chance to ask questions and discuss their own water issues with members of the panel at the isotope hydrology afternoon session at the Scientific Forum (photo: IAEA).

Note

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Contributions to the newsletter are welcome.

Santa Elena's Success Story

Scientific Forum Moderator, BBCs Nik Gowing, interviews Ecuadorian representatives Miller Muñoz Soriano and Gricelda Herrera Franco at the Scientific Forum (photo: IAEA).

Success in improving the water situation of Santa Elena peninsula residents in Ecuador — due to the team work of the IAEA, an area university and local water managers — was publicly discussed and lauded at the 2011 Scientific Forum.

The university Escuela Superior Politécnica del Litoral (ESPOL) applied to the IAEA for support some years ago, and the first IAEA Technical Cooperation project began in the area in 2007, leading to solutions to obtain water and the first permanent water supply in 2009. This has boosted the economic situation of the area's 250 000 inhabitants.

Representatives from Santa Elena attended the Forum to discuss their story, after being invited by IAEA Director General Yukiya Amano during a visit he made to the site in July 2011. Director General Amano was impressed with the cooperative nature of the project, as well as the incentive of local people in taking charge of their water situation and their involvement in finding solutions.

The IAEA has contributed to training, provided experts, equipment, mapping tools, as well as a solid foundation for the project to grow on. "From a scientific point of view it is not a breakthrough. What makes it different is the social component," said Luis Araguás Araguás, a scientific officer from the IAEA's Isotope Hydrology Section. "The involvement of the community ensures the outcome of the project belong to them."

The university wanted community involvement, and the project was first presented to the regional water board, in particular to Miller Muñoz Soriano, president of the local Manglaralto regional water board in the north of the peninsula, said Gricelda Herrera Franco, an ESPOL counterpart who was interviewed at the Scientific Forum. "It was very welcome by the whole community and has been taken up as a model for the rest of the region of Santa Elena."

The project has been very beneficial for his community, said Muñoz Soriano at the Forum. "Five years ago we had to do everything from our own calculations, today we can use the techniques that have been given to us by the Agency."

The relationship between the university and local water board has been of critical importance in the success of the project, according to Herrera, "… because although the project is of a technical nature, it must have a social impact, and this social impact can only be brought about if there is a direct relationship with the community."

'It was very welcome by the whole community…' — Muñoz Soriano

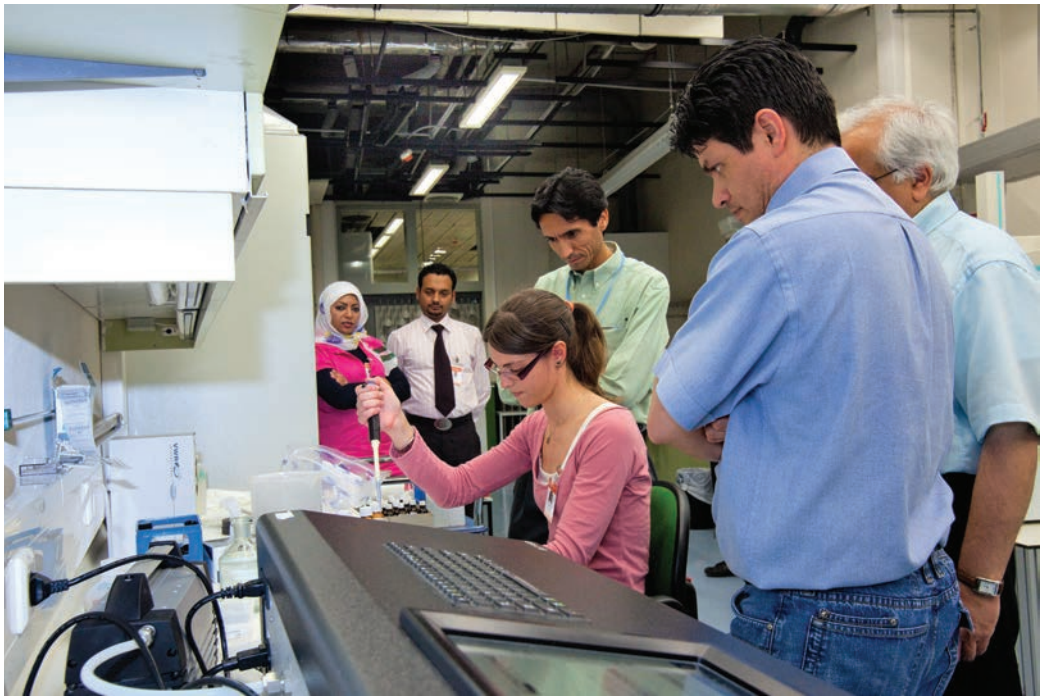
Muñoz Soriano added that in light of the success of this project, the community is thinking about how to work together with the university to find ways in the future to capture water from rain or recycling so that it can be recharged into the local aquifer. In addition, courses and seminars are being held to educate people in the community about the source of their water and how to take care of it.

Isotope techniques provided information about large aquifers in the north and south of the peninsula, said Herrera Franco. "In the northern area waters are very young, that means that the recharge of this water takes place in a very dynamic way, whereas in the south the waters are older and the recharge is substantially lower. So through these isotopic techniques and the application of them we are able to establish guidelines for the future development of this region."

"There is still a lot to be done," she added. "This project is only five years old. It has benefitted us, we still have a long way to go. We need a lot of support, we need training, we need transfer of equipment; we continue to need assistance."

Isotope Hydrology Laboratory Releases Results of Interlaboratory Comparison

Most laboratories have improved performance compared to previous exercises, though some individual laboratories have large deviations in results and problems in reporting analytical uncertainty.



The 2011 IAEA interlaboratory comparison exercise offered labs the opportunity to assess their accuracy against reference samples. More IH labs are participating, in part because of the growing availability of laser analysers (machine in foreground) (photo: IAEA).

The IAEA Isotope Hydrology Laboratory organized the fourth interlaboratory comparison exercise in 2011 with the participation of 137 laboratories from 53 countries engaged in routine analysis of hydrogen and oxygen stable isotope composition of water samples. Three similar exercises were carried out in 1995, in 1999 and in 2002. However, the tradition of IAEA water stable isotope interlaboratory comparison stems from the 1960s and 1970s.

History

Intercalibration of results obtained in different laboratories or with different measurement techniques has always been a major problem in all scientific fields. To ensure comparability of results, measurements made on common samples in diffferent labs have to be evaluated together.

These problems existed in isotope hydrology until the mid 1960s. Two main water samples were available from the US National Bureau of Standards (today the National Institute of Standards and Technology), the first of which — distilled water from Potomac River, code NBS-1 — was of special importance because it was the reference used by H. Craig in the early 1960s for defining the isotopic composition of the so-called Standard Mean Ocean Water (SMOW).

The first intercomparison was undertaken by the IAEA in 1966 when three water samples prepared with the collaboration of Willi Dansgaard at the Biophysical Laboratory of the University of Copenhagen were distributed to many labs. These were: (1) a groundwater sample of unknown source, (2) a sample obtained by mixing sea water from the Kattegat and the Baltic Sea, and (3) a surface water sample from Greenland derived from melting ice. Sample (2) imitated the isotopic composition of SMOW defined by Craig.

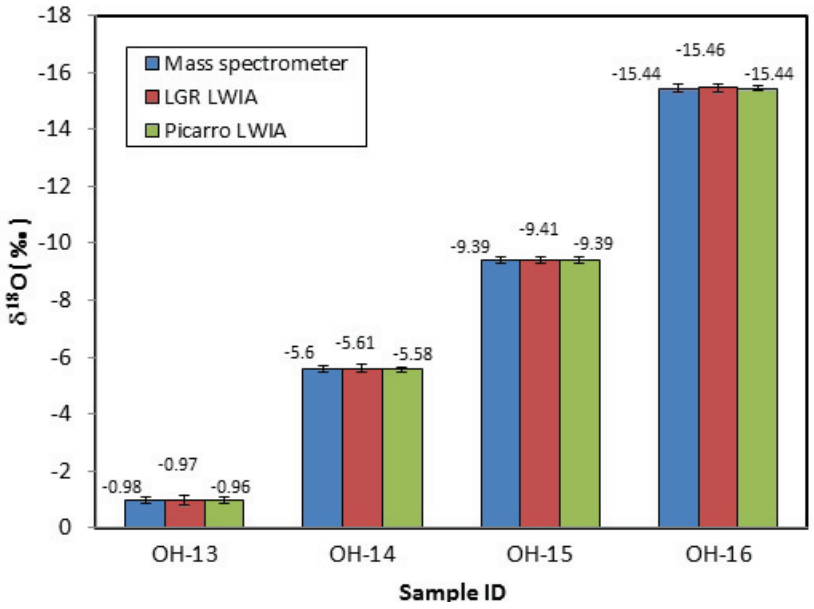
The results were discussed by a panel of experts convened in Vienna by the IAEA, and published in Science: the agreement was reasonably good, but improvements were desirable. However, the groundwork had been laid.

WICO2011

The WICO2011 included prepration and calibration of four water samples at the IAEA Isotope Hydrology Laboratory; these were labelled IAEA-OH-13 to IAEA-OH-16, or OH-13 to OH-16. The four samples cover the range of $\delta^{18}O$ and $\delta^{2}H$ values typical for the majority of natural waters. The samples were taken from 20 L stainless steel storage barrels and bottled into 50 mL bottles, serially numbered at the time of filling.

The number of participating laboratories in WICO2011 is double the number of participants for WICO2002, mainly due to the revolution brought about by laser water isotope analyzers. It also shows increased interest in the application of environmental isotopes in hydrology and other disciplines.

No significant dependence of the obtained δ values on the type of analyzer used could be found, and the performance of laser water isotope analyzers and mass spectrometers seems similar.



Comparison of average $\delta^{18}O$ values of four samples determined from the results of mass spectrometers and laser based water isotope analyzers.

Evaluation and presentation of data

The statistical analysis of the submitted results was undertaken with the major objective of assessing the performance of individual laboratories (precision and accuracy) with respect to the reference $\delta^{18}O$ and $\delta^{2}H$ values for the four analysed samples (see graph next page).

To reach this goal, a two stage statistical treatment, adopted in previous IAEA interlaboratory exercises of a similar nature, was applied to the entire population of submitted results. In stage I of the statistical treatment, obvious outliers were discarded based on the frequency distribution of values. The provisional mean compiled after stage I was further used for the stage II outlier-rejection procedure. In stage II of the evaluation process, the remaining results were assessed for each laboratory through examination of the difference between the reported isotope result x and the provisional mean m of stage I, divided by the standard uncertainty s quoted by the given laboratory. The results for which the ratio $|(x-m)|/s$ was larger than 2 were discarded, implying a significant deviation from the expected concordance of results. This procedure identified those results which were seriously overestimating their measurements precision. In the final step, the weighted average was calculated by weighing the individual results by the reciprocal of the quoted variance.

Presentation of results

Before rejecting outliers using statistical methods, the average values of $\delta^{18}O$ and $\delta^{2}H$ for the samples, along with associated standard deviations at 1σ-level and the total number of data were determined. Long term laboratory uncertainties were provided by only 45 laboratories, therefore the stage II evaluations were done using: (a) standard deviations associated with present measurements, (b) the maximum of the measurement and long term standard deviations.

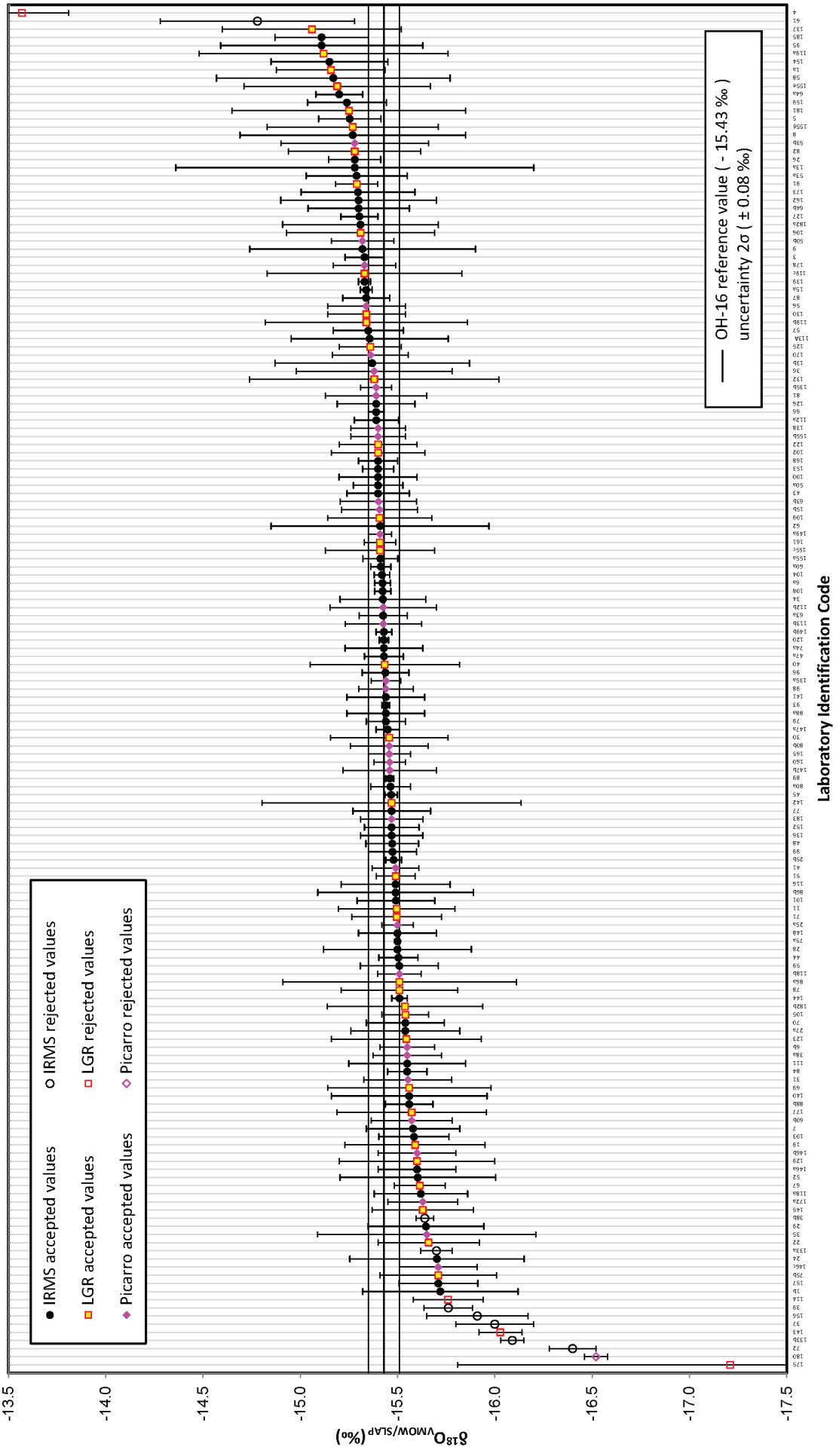
A large spread of uncertainties became apparent. For a considerable number of laboratories the uncertainties are of such an order of magnitude that measured data could not be used in a meaningful way in hydrological applications. This is recognized, but was not used as acceptance criterion in the evaluation, since the exercise was intentionally open to all laboratories measuring stable isotopes in water samples and was not limited to isotope hydrology laboratories.

A majority of laboratories have proven themselves capable of providing high quality data which can be used for hydrological/hydrogeological studies.

Precise calibration seems to be a possible bottleneck for those laboratories which still are subject to considerable offsets from reference values. The basic requirement remains to suitably calibrate and store internal laboratory water standards.

The WICO2011 interlaboratory comparison has been helpful in detecting potential problem areas for laboratories. There is still a considerable fraction of laboratories with basic problems with accuracy, precision, and in calculating justifiable measurement uncertainty. Some improvements will be suggested to individual laboratories having large deviations in results and uncertainty problems.

In order to obtain information on the relative performance in order to compare the performance of the laboratories which participated in WICO2002 and/or WICO1999, cumulative deviations from the reference values for all four $\delta^{18}O$ and $\delta^{2}H$ results were plotted in the form of bar charts. Most of the laboratories have improved performance compared to previous exercises. The full report is available online at www.iaea/water.



S shaped plot for $\delta^{18}O$ values of sample IAEA-OH-16 as shown in the WICO2011 interlaboratory exercise report.

IWAVE Pilot Studies Now Filling Priority Gaps in Hydrological Data and Information

The Philippines, Oman and Costa Rica are working with the IAEA to fill gaps in hydrological data and information identified by the IWAVE pilot studies.

Meetings were held at the IAEA for Costa Rica (left), the Philippines (right) and Oman (below) (Photos: IAEA).

The three pilot studies of the IAEA Water Availability Enhancement Project (IWAVE Project) have successfully identified and profiled national level gaps in hydrological data, information, and understanding that are hindering these Member States' ability to conduct comprehensive water resource assessments.

Each of these pilot studies — in the Philippines, Oman and Costa Rica — is now in the midst of implementing an increasing number of activities specifically designed to address individual identified gaps.

Through these pilot studies, IWAVE intends to develop and evaluate methods and approaches to assist Member States to identify and fill gaps in hydrological data and information. Gaps in hydrological data and information are particularly acute with respect to groundwater resources, which represent about 97% of the Earth's easily recoverable fresh water. Each pilot study will determine the expertise, technology and infrastructure support required to fill identified gaps, including utilizing a full range of isotope techniques. By filling the gaps in hydrological data, information, and understanding and strengthening the capacity of Member States to conduct comprehensive assessments, the availability of fresh water in these countries will be enhanced. Fully realized comprehensive assessments conducted by Member States would quantify water quality, water quantity and water use, as well as resource vulnerability and sustainability.

Recent activities of each of these three pilot studies is described below.

Philippine IWAVE Pilot Study

The Philippines IWAVE Pilot Study is being conducted in collaboration with the Philippine Nuclear Research Institute and the Philippine National Water Resources Board. Recent work includes:

— IAEA Workshop, Oct 31–Nov 4, 2011, with participation by five scientists representing the National Water Resources Board, the Philippine Nuclear Research Institute, and the Department of Environment and Natural Resources, Mines and Geosciences Bureau. The meeting provided:

• Organization and finalization of the content of a report presenting the National Plan to address gaps in hydrological understanding, data, and information;

• Finalization of plans and details for an upcoming national workshop (March 12–16, 2012) to enhance and accelerate current national programmes quantifying groundwater resources;

• Establishment of technical needs to fill four additional priority gaps in data and information with specific activities and dates under discussion for implementation in 2012.

Oman IWAVE Pilot Study

The Oman IWAVE Pilot Study is being conducted in collaboration with the Peaceful Nuclear Technology Office of the Ministry of Foreign Affairs and the Ministry of Regional Municipalities and Water Resources. Recent work includes:

— One-month consultancy at the IAEA by a hydrologist of the Ministry of Regional Municipalities and Water Resources of Oman between November 14–December 9, 2011. In this time the consultant:

• Compiled, documented, and evaluated Oman's historical water isotope data, exploring one approach to establish this critical information base for future isotope hydrology studies.

— IAEA Workshop, December 12–16, 2011, with participation by six scientists representing the Ministry of Regional Municipalities and Water Resources, Sultan Qaboos University, and Petroleum Development Oman. The workshop provided:

• Review and refinement of the specifics of primary gaps in hydrological data, information and understanding;

• Development of a 2012 action plan and timetable for specific workshops, training, and field activities.

Costa Rica IWAVE Pilot Study

The Costa Rica IWAVE Pilot Study is being conducted in collaboration with the Embassy and Permanent Mission of Costa Rica in Vienna and the Ministry of Environment, Energy and Telecommunications. Recent activities include:

— IAEA Workshop, Nov 28–Dec 2, 2011, with participation by five scientists representing the Ministry of Environment, Energy and Telecommunications (MINAET), the Institute of Water Supply and Sanitation (AyA), and the National Service for Groundwater, Irrigation, and Drainage (SENARA). The workshop provided:

• Identification of primary gaps in hydrological understanding, data and information;

• Development of a 2012 action plan and timetable for specific workshops, training and field activities.

For further information contact Charles Dunning at C.Dunning@iaea.org

Water sampling in Costa Rica (photo:IAEA).

News in Brief

Departing Staff Members

• Brent Newman joined the Isotope Hydrology Section staff in October, 2006. During his five year stay in the section he worked on a variety of TC projects in Africa, Asia, and the Middle East. Brent was also involved with Coordinated Research Projects on the use of isotopes to improve water use efficiency in irrigated agriculture, estimation of basin scale recharge, and the use of isotopes to understand the hydrology of snow and ice dominated lands. He also worked extensively on procedures and training for the laser absorption based isotope analysers and supported section activities related to programme planning and implementation. Brent has returned to his former position at Los Alamos National Laboratory in the United States of America where he continues to work on isotope projects.

Arriving Staff Members

• Leonard Wassenaar recently joined the Isotope Hydrology Section as Team Leader for the Isotope Hydrology Laboratory in January 2012. For the past 20 years, Wassenaar was research director for Environment Canada's Isotope Hydrology and Ecology Laboratory at the National Water Research Institue located in Saskatoon, Canada. He is an adjunct professor in the Department of Geological Sciences at the University of Saskatchewan, and a fellow of the Canadian Rivers Institute in New Brunswick. He has been involved in diverse interdisciplinary stable isotope research, ranging from groundwater resource evaluation, contamination and remediation, aquatic and terrestrial ecology, and surface and river water resources assessment and evaluation, and has also published a book on the use of stable isotopes in animal migration. He has published varied methodologies for isotopic measurements of environmental samples, using conventional mass spectrometry and newer laser based methods. In the section, Wassenaar will be supervisory Team Leader for the Isotope Hydrology Laboratory, and will also work as Co-Project Officer for the CRP on isotope methods to assess water quality in rivers and groundwater.

• Hamid Marah joined the Isotope Hydrology Section as consultant in November 2011. He obtained his post-graduate diploma (Doctorat de Troisième Cycle) in Applied Nuclear Physics, and PhD in isotope hydrology. His research over the past decade has focused on the use of isotopic tools and nuclear techniques in the study of the water cycle and the development of analytical isotopic methods. Marah was previously a Head of the CNESTEN's Water and Climate programme, a Project Scientific Consultant of a regional isotope hydrology project in Africa, and Director of Regional AFRA Designated Centres to support African Member States in training and analytical services regarding isotopes. He conducted/participated in several case studies on groundwater and surface water using environmental isotope and nuclear techniques. The reports of some of these case studies have been published in the IAEA Atlas of Isotope Hydrology of Morocco, the first national atlas which provides an important scientific base for water resources (particularly groundwater resources) development in Morocco. His main duties in the Isotope Hydrology Section will be to assist in the implementation of IWAVE (the Water Availability Enhancement Project) recently launched by the IAEA and to further develop tritium measurement procedures in the Isotope Hydrology Laboratory.

• Dagnachew Legesse joined the Isotope Hydrology Section as a consultant in February 2012. Mr. Dagnachew was previously an Associate Professor at Addis Ababa University in Ethiopia. He has conducted research on environmental hydrology and geospatial date management. He has been teaching postgraduate courses in hydrology, GIS, Remote Sensing and Data Management. He has also served as an assistant dean of the science faculty. In the section, he will be assisting in implementing projects in isotope hydrology and in IWAVE.

• Bhishm Kumar joined the Isotope Hydrology Section as a consultant in January 2012. Kumar was previously a senior scientist and Head of the Hydrological Investigations Division at the National Institute of Hydrology (NIH), Roorkee, India. He has established a world class isotope hydrology laboratory at NIH Roorkee and conducted integrated hydrological studies of lakes and groundwater using isotopes. He also designed and had fabricated tritium enrichment units at his institute, the performance of which was found to be excellent during the sixth low level environmental tritium inter-comparison exercise (TRIC 2000) organized by the IAEA. He established the Indian Meteoric Water Line (IMWL) and several regional and local meteoric water lines for India. He initiated several useful and important hydrological studies in India using isotopes. He was one of the National Principal Investigators and major partner of a mega programme going on in India (2007–2012) for the isotope fingerprinting of waters of India (IWIN). In the section he will be responsible for the isotope hydrological investigations to be carried out under IWAVE in Costa Rica (Central America) and will work as Co-Project Officer for the Coordinated Research Project on the use of environmental isotopes to assess sustainability of intensively exploited aquifer systems (2012–2015).

Participants discuss tritium analysis at a meeting held in the Isotope Hydrology Lab in Vienna (story below). (photo:IAEA).

Meetings

• A consultants' meeting on Current Practices and Requirements for Tritium Analyses in Isotope Hydrology, held in Vienna in December 2011, was undertaken to exchange experiences and discuss problems, possible solutions and improvements to current practices relevant to the use of environmental tritium in isotope hydrology.

Tritium in precipitation, surface water and groundwater is lower than it has been in the past, thus improved analysis is necessary to accurately read and process tritium data. For this reason, the Isotope Hydrology Section organized a meeting involving countries from Southeast Asia and the Pacific to identify current performance standards and explore how to improve these.

Participants described their current systems and problems they face in attempting to provide more precise measurements and analysis. Each participant presented information on the same laboratory procedures, including: primary distillation, enrichment, counting and counter, result and standards and background/blank. They also presented the problems they encountered within these tritium measuring steps, and for each problem suggestions and recommendations were proposed to improve the situation.

The goal of the meeting was to get a perception of the needs of Member States so that the IAEA laboratory can assist Member States in improving their performance. For further information, contact Manzoor Choudhry at M.Choudhry@iaea.org.

• A tips and tricks document was produced as an outcome of the Liquid Isotope Analyzer Users Meeting held at the IAEA in November, 2011. The document expands on an earlier tips and tricks document, released in 2009, which is also available on the website. Both report on the experiences of laser analyser users and answer typically undocumented questions and problems that have arisen during the operation of these instruments. Participants identified the most important factors associated with the performance of the instrument to be sample volume, machine stability and syringe longevity, and proposals were recommended based on this feedback. The tips and tricks mentioned in the paper have not been tested by the IAEA, and so are to be used with caution and discretion. The complete document can be found on the Water Resources Programme website at www.iaea.org/water.

Obituary

• Antonio Plata Bedmar, a former staff Member of the Isotope Hydrology Section (October 1984 to June 1993) and a pioneer in Spain on the use of isotope techniques in hydrology, passed away in Madrid in October 2011 at the age of 79. After obtaining his degree in Chemistry, he received specialized training in Germany on the development and use of nuclear techniques in hydrology, medicine and other environmental applications. Since the late 1950s to 1986 he worked in Spain at the former Nuclear Energy Board (JEN), the Office of Nuclear Applications for Public Works (GANOP) and the Centre for Studies and Experimentation of the Ministry of Public Works (CEDEX). Under his leadership, the first isotope hydrology laboratory, with the capability of measuring the environmental radionuclides for groundwater dating, was created in Madrid, Spain (in 1970 tritium and carbon-14 in 1972). Also in the 1970s, the first mass spectrometer for analysis of stable isotopes (oxygen-18, deuterium and carbon-13) in hydrological applications became operational in the same centre. Antonio Plata participated in many of the pioneering isotope studies of groundwater bodies, including the use of both artificial tracers and environmental isotopes. Between 1984 and 1993, he became a Technical Officer at the IAEA's Isotope Hydrology Section. In that capacity, he conducted numerous projects and studies addressing hydrological assessments and characterizations in almost all Latin American countries, where his name is well known, and in some African countries. During his fruitful career, he wrote numerous technical reports, scientific articles and books. In addition, he taught courses and lectures both in Spain and in many other countries as IAEA staff or expert. Until his retirement, he worked as head of the Isotope Hydrology Unit at CEDEX in Madrid. His many colleagues and friends will miss her friendly nature, energy, and the contagious enthusiasm with which he dealt with everything in his life.

CRP Studies Isotopes in Recharge Estimation

Participants in the second research coordination meeting for the project on Use of Environmental Isotope Tracer Techniques to Improve Basin-Scale Recharge Estimation (photo: IAEA).

The second research coordination meeting (RCM) of the Coordinated Research Project on 'Use of Environmental Isotope Tracer Techniques to Improve Basin-Scale Recharge Estimation' (CRP 1529) was held in Vienna from 5–9 December 2011. Ten researchers from nine countries, including observers, participated in the meeting.

This CRP has two major goals: to encourage utilization of environmental isotopes in recharge estimates and advanced mapping and spatial calculation technologies — namely Geographical Information Systems (GIS) — to upscale point or localized recharge estimates to the basin scale.

Environmental isotope tracers are valuable tools that can offer significant insight into recharge processes, often with fewer infrastructure requirements and at lower cost than other methods. However, because environmental isotope methods typically yield point or local scale recharge estimates, a method for upscaling is needed for estimating basin scale recharge.

Groundwater recharge is under the control of several basin characteristics such as climate, vegetation, soil type, geology, topography, and land use. GIS is a powerful tool in the upscaling process because it can incorporate all these factors in a spatially continuous analysis of recharge. Ideally, correlations between local isotope based recharge estimates and basin characteristics could be combined with map layers of basin characteristics in a GIS to extrapolate recharge estimates to the basin scale.

The eight case studies in this CRP represent a broad range of climatic, geologic, hydrologic, topographic, and vegetation conditions. As a result, the conceptual models of recharge sources, distribution, timing, and rates varied greatly between study areas. Nonetheless, the approaches adopted provide templates that can be applied in a very wide range of hydrologic settings which will eventually achieve the overall CRP objective. Thus, local isotope based recharge estimates provide important empirical data and process information needed for testing and improving GIS and numerically based extrapolations of recharge data. A final document summarizing similarities and differences in approaches and results obtained in the case studies with respect to achieving overall CRP objectives will be an important outcome of this CRP.

Regional Training Workshop for Nile Basin

A two week regional training workshop on water balance modelling of the Nile basin was conducted at the IAEA headquarters in Vienna between 05–16 December 2011. The workshop was organized under an ongoing IAEA-GEF/UNDP project entitled: Adding the Groundwater Dimension in the Nile Basin Water Resource Management (RAF8042).

Fourteen participants from eight Nile basin countries, namely: Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Rwanda, Sudan, United Republic of Tanzania and Uganda attended the workshop. This is the third regional training workshop organized as part of capacity building under the above mentioned project. There will be two more training courses in 2012 before the project is closed by the end of the year.

The training course covered intensive theoretical and practical exercises on water balance modelling and

Participants in a regional training workshop for Nile Basin countries. (photo: IAEA).

the coupling of isotopes in hydrological models. An introductory lecture on isotope hydrology was given and participants visited the IAEA's isotope analytical facility.

At the beginning of the course, each county made a short presentation on the hydrology of Nile sub-basins. All participants have a basic to advanced background in water resource sciences and engineering. Some were university professors and some hydrologists from ministries of water resources. The course was organized to provide input to project implementation, with the hope of enhancing project delivery or outputs.

Dr. George Leavesly, formerly of the US Geological Survey and currently at Colorado State University and programmer and author of the PRMS hydrological model, presented the course together with Dagnachew Legesse (PhD), a hydrologist and GIS-RS expert from Addis Ababa University.

CRP on Quantification of Hydrological Fluxes

The third and final Research Coordination Meeting for CRP 1429, Quantification of Hydrological Fluxes in Irrigated Lands Using Isotopes for Improved Water Use Efficiency was held in Vienna from September 5–9, 2011. The overall objective of the CRP was to enhance the application of water use efficiency techniques in irrigated lands at the field and basin scales in Member States. The focus was the development and implementation of isotope methods for quantification of two of the major fluxes (deep percolation and evaporation) that control the water balance of irrigated lands, and therefore are a measure of the degree of water use efficiency.

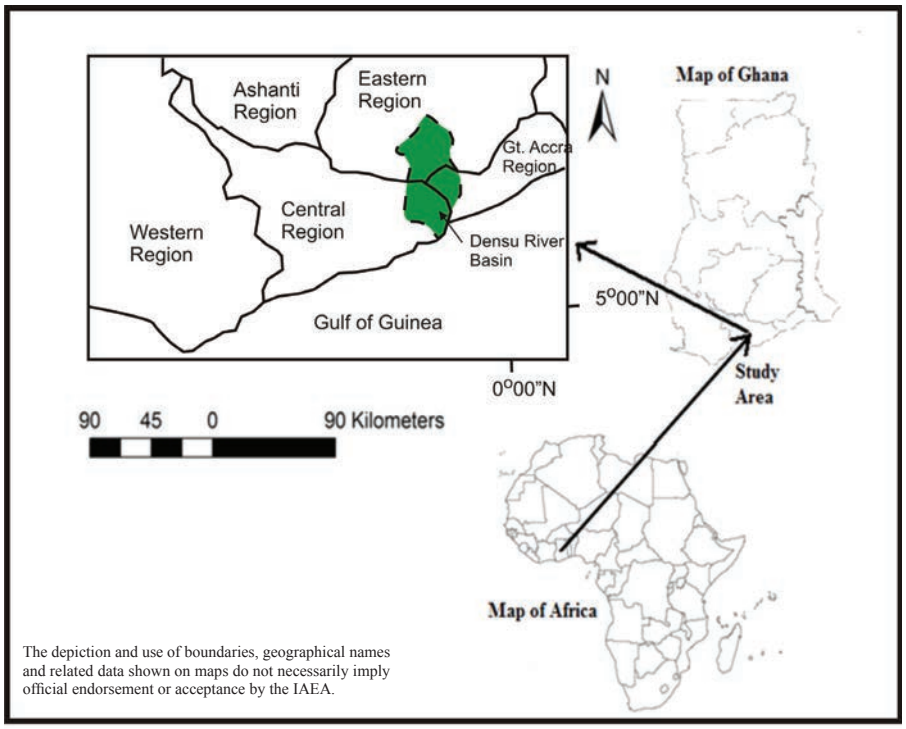
Participants in the third and final research coordination meeting for the CRP Quantification of Hydrological Fluxes in Irrigated Lands Using Isotopes for Improved Water Use Efficiency (photo: IAEA).

Ten research projects focused on the collection of isotope data in precipitation, soil water, percolation water, groundwater, atmospheric vapour, and plant water samples as well as meteorological data. The majority of the studies were carried out as field experiments, but investigations in the laboratory were also performed. The data were collected from different climate areas, soil types, crops, and using different types of irrigation setups. Projects were carried out in humid, semi-arid and arid regions. Soil types ranged from sandy to clay materials. A broad variety of agricultural and orchard crops were studied (e.g. corn, wheat, rice, cotton, sugarcane, orange tree, apple tree, olive, spinach, as well as grass and bare soil). The investigated irrigation methods included sprinkler, flood, rain-fed, and drip techniques. The breadth of the experiments should make the CRP results more useful for understanding impacts of crops, irrigation method, etc. on water use efficiency, and these results will be expanded and explored further in a publication which is in preparation. CRP results were sufficient to clearly indicate the large effect of irrigation practices on water use efficiency. Some studies showed deep drainage pulses that occurred after irrigation events that have no benefit to crops and could potentially transport fertilizers and other contaminants to groundwater. Such pulses can also contribute to water logging through rising groundwater tables. The isotope results also indicate issues related to evaporation losses which also lower WUE from the crop perspective. For example, irrigation by flooding was shown to result in higher evaporative losses than other methods. In addition, isotope results show how strongly evaporation varies under different crop types. This difference can be seen by the variation in soil water slopes (oxygen-18 versus deuterium relationship) where crop slopes vary from 3 to over 6.

Comparisons between classical hydrological methods and isotopic investigations also show good agreement. Isotopic approaches are very applicable to agricultural water use problems and they have advantages in that they do not require special field instrumentation and can be used to provide estimates of evaporation and transpiration fluxes that are difficult to be derived with other methods. Participants in the RCM included Xianfang Song (China), Naveed Iqbal (Pakistan), Andreas Klik (Austria), Kamel Zouari (Tunisia), Christopher Watts (Mexico), Fatima Raibi (Morocco), Boulos Abou Zakhem (Syrian Arab Republic), Jochen Wenninger (Netherlands), Dan Yakir (Israel), Shakeel Ahmed (India), and Brent Newman (IAEA).

Isotope and Hydrochemical Techniques Used to Investigate Groundwater in Ghana

By S. Osae, D. Adomako, J.R. Fianko, S. Ganyaglo (Ghana Atomic Energy Commission, Accra, Ghana), B.K. Kortatsi, C. Tay (Water Research Institute, CSIR, Accra, Ghana), T. Vitvar (Czech Technical University, Prague, Czech Rep.), L. Gourcy (BRGM, France), M. Ito (IAEA)



Map of the region studied, along the Gulf of Guinea.

Ghana is located a few degrees north of the Equator in West Africa, along the Gulf of Guinea (see above). The climate is tropical with wet and dry seasons, though the extent of the seasons differs between regions. Ghana has relatively ample water resources, including the Volta River Basin, which covers about three quarters of the country (Andreini et al., 2000). However, water quantity and quality has gradually declined in major river systems in the country over the past 30 years.

The surface water of the Densu River, one of the four major rivers in the coastal water system of the country, is highly contaminated and thus groundwater has become the principal source of water to the communities in the Densu Basin, where important urban centres are located. In the central region, groundwater is also an important drinking water source, owing to seasonal limitations in surface water availability. But water quality in many boreholes has been found to be unsuitable for drinking, due to high electrical conductivity (high salinity up to 5000 µS/cm; Armah, 2002) and elevated iron, manganese and fluoride concentrations (WRCSL, 2008). The lack of safe drinking water and sanitation is considered to be a major cause of disease in the country (OECD/AfDB, 2007). With domestic water demand increasing, and agricultural, mining and industrial activities in the concerned area growing, a safe drinking water supply has become a national priority.

Ghana has had two national Technical Cooperation (TC) projects with the IAEA in the field of isotope hydrology and participated in a few regional TC isotope hydrology projects. Based on these experiences, recent and current national TC projects have been implemented jointly by the Ghana Atomic Energy Commission (GAEC), the Ghana Water Resources Commission and the Water Research Institute, with the more specific goal of investigating groundwater systems as part of an integrated water resource management programme and in more focused geographic areas. A recent project, GHA8008 (2005–2010), examined the Densu River Basin, and ongoing project GHA 8009 (2009—in the final stage) focuses on the central region. Ghana also participates in a regional TC project entitled Building Capacity in Support of Regional and Sub-regional Water Resources Planning, Development and Management in Africa (AFRA), which started in 2009.

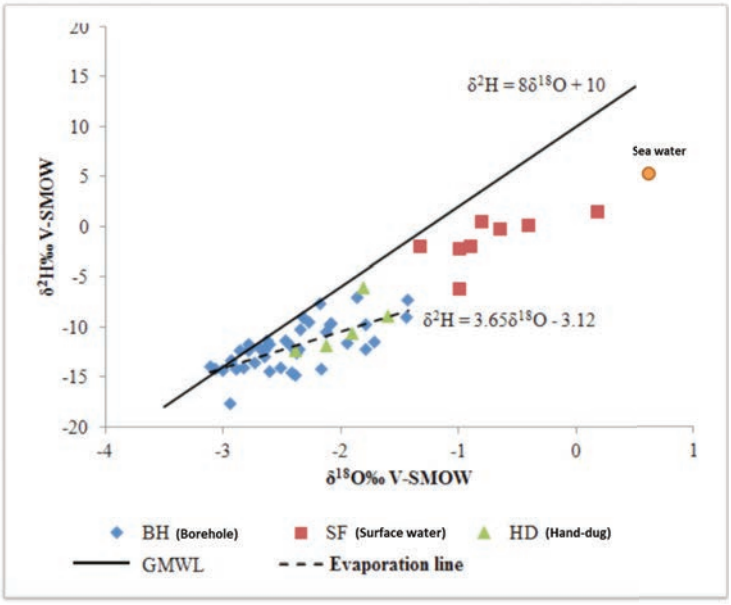
The Densu River Basin

One of the main objectives of the two currently operating projects is to identify salinity sources at the respective study sites. For project GHA8008, entitled Isotope Techniques for Assessment of Groundwater Resources in the Densu River Basin, groundwater and surface water samples were collected five times between 2005 and 2008. Isotope and hydrochemical analyses showed that: (a) all groundwater samples were within the same range of stable water isotope ($\delta^{18}O$ and $\delta^{2}H$) values with no or minimal spatial and temporal variation, the isotope values of water samples with high salinity were not different from those of fresh groundwater, and no relationship exists between conductivity or $Cl/Na/SO_4/Mg$ concentrations versus stable water isotope values. These results suggested similar water sources for all groundwater samples in the entire basin and/or the need for approaches other than stable water isotopes in the identification of salinity sources; (b)

water isotope values in precipitation, surface water and groundwater suggest that aquifers are mainly recharged via direct precipitation; and (c) no correlation is found between tritium values and salinity, and high salinity water is not the deepest or the oldest groundwater. Together with hydrochemical analyses, the results did not indicate that salinity was of seawater origin at the Densu Basin study sites. A large part of the study in the Densu River Basin has also been presented in an article by Gibrilla et al. (2010), among others.

The coastal zone of the central region

One ongoing project, GHA8009, entitled Integrating Isotope Techniques in National Groundwater Resources Assessment, focuses on the central region. Groundwater (boreholes (BH), hand-dug (HD) wells) and surface water (rivers and a pond) were collected in May 2009, December 2009 and December 2010, as well as rainwater (at two meteorological stations) from December 2009 to December 2010. Stable water isotope values from BH and HD groundwater samples were similar, and all groundwater samples showed a stable water isotope slope ($\delta^{18}O/\delta^{2}H$) of 3.65, below the Global Meteoric Water Line (GMWL) (see fig. below). Considering the relatively shallow borehole depths (mean depth: 33.7 m; ranging between 18 m and 90 m) and the relationship between EC or Cl and $\delta^{18}O$, groundwater may be affected by evaporation. Surface water samples had distinctly different stable water isotope values from those of groundwater, with more enriched values. These results suggest no interaction between surface water and groundwater in the study area. Tritium values were low (1.29 to 1.96 TU; mean 1.54 TU), suggesting direct infiltration of relatively recent precipitation in the sampled area. Carbon-14 values of the majority of groundwater samples were between 87 and 114 pMC, suggesting modern groundwater, while one groundwater sample had a much lower ^{14}C value (10 pMC), which is considered to be old groundwater. The plots of ^{14}C vs. $\delta^{18}O$ and ^{14}C vs. ^{13}C show a clear difference in ^{14}C activity between the two groups. The age or residence time of this older groundwater was estimated to be 18 000–20 000 years, based on theVogel, Ingerson-Pearson and Fontes-Garnier models. The results of isotope analyses as well as hydrochemical analyses suggest the influence of silicate weathering and the minimal role of seawater in the high salinization of groundwater from the study sites.



All groundwater samples showed a stable water isotope slope ($\delta^{18}O$ / $\delta^{2}H$) of 3.65, below the Global Meteoric Water Line (GMWL).

Both projects reveal that seawater intrusion is not particularly responsible for high salinity in groundwater in either the Densu River Basin or the coastal zone of the central region. In the central region, the terrain is without significant topographical gradients and there are at least two types of aquifers; one in schist which is not highly recharged and the other in fluvial sediments with a higher rate of recharge, and thus more subject to pollution. Efforts are continuing to better identify groundwater flow directions beneath this complex terrain and evaluate the possible origins of old groundwater components. In addition, isotopic analytical capability is being built in the country, including facilities for the analyses of stable water isotopes and tritium. Ghana has been making progress toward advanced knowledge and capacity capabilities in isotope hydrology.

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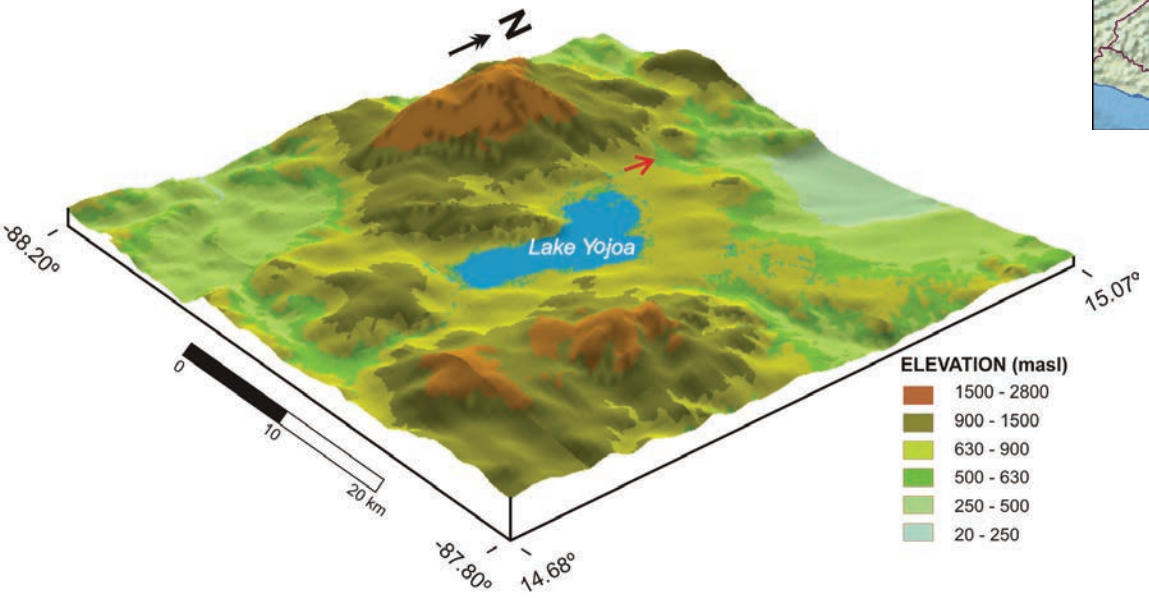
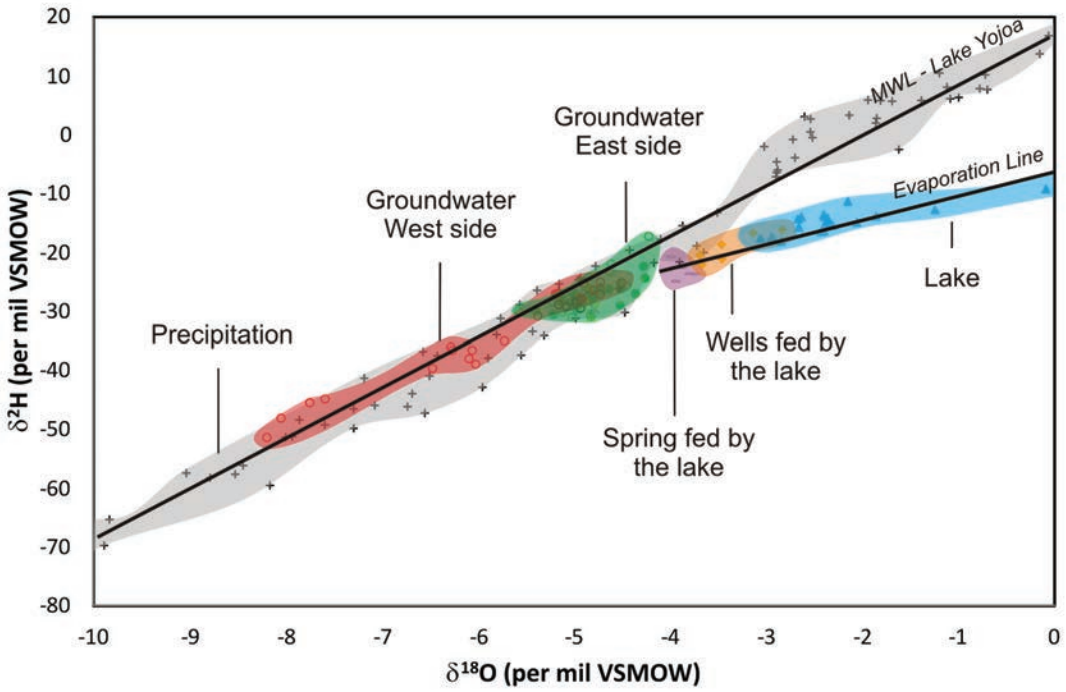
Using Isotopes to Improve Water Balance Estimates of Lake Yojoa Basin in Honduras



Digital terrain model of the Lake Yojoa basin (topography exaggerated 200%). The red arrow in the North of the Lake indicates the area of natural discharge through a channel and springs. Above is a map of Honduras with the location of Lake Yojoa.

Lake Yojoa is the largest fresh water body in Honduras. It has an area of 280 km^2 and is considered a strategic natural resource for this country; in fact, important sectors of the Honduran economy depend on it, including the fishing industry, agriculture and tourism. It is also used to generate electric power. In the last decade, acute water use conflicts between basin users have increased. For this reason, good knowledge of water balance, accounting for all inflows and outflows of the lake water, are a required point of reference for the establishment of an appropriate management plan for the lake.

Since 2007, the IAEA has been funding and advising the National Company of Electric Energy of Honduras (ENEE) to improve estimates of the water balance in the watershed that feeds the lake. Studies have been implemented within the framework of two Technical Cooperation projects, and include the measurement of stable isotopes deuterium and oxygen-18 in the water in order to improve existing water balance estimates via isotopic methods, which are being used as a complementary tool to traditional hydrological



The δ^2H-$\delta^{18}O$ plot for groundwater in the Lake Yojoa Basin. Local precipitation is also shown. The spring and wells fed by the lake are located in the north of the basin.

methods. Both projects have also motivated the use of hydrochemical methods to complete the hydrological study, and have enabled the ENEE to improve its observation network for meteorological variables.

In order to strengthen the use of nuclear techniques in hydrological studies in Honduras, the IAEA has promoted the creation of the first isotope hydrology laboratory in this country through the procurement of a laser isotope analyser and the training of ENEE personnel in its operation. With this instrument, Honduras now has the capacity to measure deuterium and oxygen-18 in water samples and, for this reason, Honduras can now undertake similar studies in other regions of the country.

The ENEE is the biggest user of Lake Yojoa. Since the 1960s, it has been collecting meteorological information in this region systematically, but until 2007 there was only partial knowledge of basin dynamics because water balances hitherto carried out did not take into account the groundwater component. With the addition of isotopic methods, it has been possible to identify and quantify the role of aquifers in the water balance and, thus, insight into the lake's dynamics has been greatly enhanced. Besides water balance consideration, the project addresses other areas, such as water quality and interaction between lake water and the local aquifer. Through this work, the Honduran government will have better hydrological information that will allow it to make positive decisions for the management and care of Lake Yojoa.

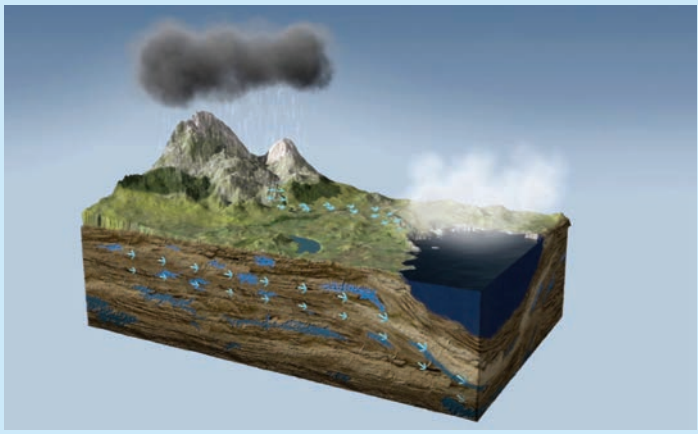
For more information contact Luis Toro Espitia at L.Toro-Espitia@iaea.org

Samples being taken from Lake Yojoa (Photo: ENEE).

Animation on Isotopes in Hydrology

The Water Resources Programme has completed a five minute animated film explaining how isotopes work within the water cycle, and how isotope hydrology can use these 'fingerprints' to uncover different sources of water and trace its movement. The film starts by discussing the general issues surrounding water resources and water availability, as well as the information required to properly assess water resources in terms of quantity and quality.

Later, it zooms into a water drop and illustrates the different behaviour of water molecules containing heavier and lighter stable isotopes; all water in nature has differing isotopic contents, which can be used to trace the component of the water cycle. The animation progresses into an explanation of how another set of isotopes — radioactive isotopes — are used for dating groundwater, from a few months up to a million years old. The dating



tools provide us with information about the dynamics of the water cycle, including the age, recharge rates and flow velocities of groundwater. Further development of isotopic tools for tracing the origin of water and dating groundwater is currently a strong focus of the Water Resources Programme.

The Water Resources Programme will soon be releasing the proceedings of the International Symposium on Isotope Hydrology, Marine Ecosystems and Climate Change Studies, which was held from 27 March to 1 April 2011 in Monaco. The Symposium was jointly organized by the IAEA Water Resources Programme and the Marine and and Environment Programme. It was held at the Oceanographic Museum of Monaco to commemorate the 50th anniversary of the establishmenet of the IAEA Laboratory in the Principality of Monaco. The Symposium also represented the thirteenth edition of the quadrennial Symposium on isotope hydrology and water resources management, which has been regularly organized by the IAEA since 1963.

The Symposium attracted 278 participants and observers from 67 Member States, covering aspects related to the use and application of isotope tools to address a broad spectrum of scientific disciplines through invited talks, oral and poster presentations and workshops. It addressed five major topics through invited talks and oral presentations, including: the role of isotopes in understanding and modelling climate change, marine ecosystems and water cycle; carbon dioxide sequestration and related aspects of the carbon cycle, isotopes in groundwater flow modelling for large aquifers; analytical methods and instrumentation.

Meetings in 2012

- Philippine National Workshop in Support of the Pilot Study of the IAEA Water Availability Enhancement Project, Manila, Philippines, 12–16 March.
- 6th World Water Forum, Marseille, France, 12–17 March.
- Meeting of Philippine IWAVE Pilot Study to finalize report on national gaps in hydrological data, information and understanding, Vienna, Austria, 19–23 March.
- WSTA Tenth Gulf Water conference, Qatar, 22–24 April.
- European Geosciences Union, Vienna, Austria, 23–26 April.
- 2nd RCM isotope methods for assessing the impact of climate change on water resources in snow, glacier and permafrost dominated areas, Vienna, Austria 18–21 June.
- Rio+20 United Nations Conference on Sustainable Development, Rio de Janeiro, Brazil, 20–22 June.
- HydroPREDICT'2012 Conference, Vienna, Austria, 24–27 September.
- Global Network of Isotopes in Precipitation Steering Committee, Vienna, Austria, 15–19 October.
- 1st RCM on the use of environmental isotopes to assess sustainability of intensively exploited aquifer systems, Vienna, Austria, 14–16 November.
- 1st RCM on environmental isotope and age dating methods to assess water quality issues in rivers affected by shallow groundwater discharges, Vienna, Austria, 05–07 December.

Impressum

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