

**Newsletter of the Isotope Hydrology Section**  
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*Farming in Egypt is heavily dependent on Nile waters. See p. 6 for story (Photo credit: Nile Basin Initiative).*

## From the Section Head

The Isotope Hydrology Section is excited to undertake a new initiative focused on the assessment of water resources. The project aims to assist Member States in identifying gaps in existing hydrological information and understanding, in improving capacities for collecting, managing and interpreting water resources data, and in using advanced techniques to simulate hydrological systems. The project is meant to complement other international, national and regional initiatives, and create a more detailed understanding of national water resources — including sustainability and vulnerability — and thus aid decision makers in managing their water resources in the best way possible. Pilot efforts are beginning in 2010, and the project is expected to support an expanding portfolio of national projects (p. 2).

Another IAEA initiative related to resource assessments is being undertaken in the Nile River Basin (p.6). Though many components of the basin's hydrology have been thoroughly analysed, groundwater — which is playing an increasingly important role for Nile Basin countries — has received little attention. Meanwhile, new mapping techniques undertaken for the Tadla Basin in Morocco (p. 9) have improved understanding of this aquifer system, and may be used for a visual analysis of groundwater data in other parts of the world.

We intend to include a Reader's Corner (p. 13) in upcoming editions of the newsletter to provide readers with a platform for feedback, suggestions and questions regarding isotope hydrology programmes and other issues of interest to the isotope hydrology community.

P. Aggarwal



# Water Availability to be Enhanced through Focus on National Water Resources Assessments

By C. Dunning (IAEA)

*The IAEA is undertaking a project aimed at enabling Member States to enhance the availability and sustainability of fresh water, with an emphasis on groundwater, through science based, comprehensive assessment of national water resources.*



*Many countries are lacking enough fresh water for their population, such as here in Bangladesh. The IAEA wants to help Member States define resources through comprehensive assessments to enable policy makers to reach informed decisions (Photo credit: IAEA).*

Currently, many countries are not able to sustainably manage the demands on their freshwater resources. A new initiative to enable Member States to enhance the availability of fresh water through comprehensive, scientifically sound resource assessments is being undertaken by the IAEA. This initiative, named the Water Availability Enhancement Project, will assist Member States to identify gaps in existing hydrological information and understanding, to improve national capacities for collecting, managing, and interpreting water resources data, and to use advanced techniques to simulate hydrological systems for resource management. As a result, the capacity of Member States to conduct comprehensive national water-resources assessments will be strengthened. The Water Availability Enhancement Project is envisioned to build on, and complement, other international, regional, and national initiatives to provide decision makers with reliable tools for better management of their water resources.

## History

There are significant technical and financial problems in many developing countries which make it difficult to assess the quality and availability of water resources and to plan for their sustainable allocation and use. This lack of water resource assessment and planning capacity has a negative impact on both economic development and quality of life for residents. These technical and financial problems have been recognized for many years, and documented at least as long ago as the United Nations Water Conference in Mar del Plata, Argentina, in March 1977 [1]. One important outcome of this conference was the Mar del Plata Action Plan, which lists 'Assessment of water resources' first among eight major recommendations.

Since the Mar del Plata conference, the importance of adequate water resource assessment has been emphasized

repeatedly in documents and initiatives, including the International Drinking Water and Sanitation Decade (1981–1990), the 1991 WMO/UNESCO (World Meteorological Organization/United Nations Educational, Science, and Cultural Organization) Report on Water Resources Assessment, and the International Conference on Water and the Environment in Dublin (January 1992). The importance of improving water resources assessment has also been highlighted in (among others) the 1997 WMO/UNESCO Water Resources Assessment — Handbook for Review of National Capabilities, the issues of the International Decade for Water (2005–2015), the objectives of the World Water Assessment Programme of UN Water and its series of World Water Development Reports, and the UN Millennium Development Goals.

*Currently, many countries have greater demands on their freshwater resources than can be sustainably managed.*

Achievement of the UN Millennium Development Goal of reducing by half the number of people globally without access to clean drinking water will require, among a number of steps, the ability to quantify (and deliver) surface or groundwater in different areas of a country. However, significant gaps in hydrological information and understanding persist in most developing countries, resulting in less-than-comprehensive national water resources assessments. The problem is particularly acute with respect to groundwater resources. Of the 2.5% of the earth's total water that is fresh and not salty, almost one third is groundwater; a very small proportion is found in rivers, lakes, and other surface water (two thirds is frozen in ice caps and glaciers). By far, the greatest proportion of the earth's available fresh water is located underground and this vital resource is often poorly understood and poorly managed.

Strengthening technical capacity at the national level to fill these hydrological information gaps will result in more detailed understanding of national water quantity, quality, and use, and will enable the characterization of the vulnerability and sustainability of resources, thus assisting water managers and planners in making the very difficult choices they face regarding water allocation.

## Consultants Meeting

To ensure successful implementation of the Water Availability Enhancement Project's complementary

approach and to avoid duplication with existing initiatives, the IAEA organized a Consultants Meeting, held from 4–6 May 2010, in Vienna.

Nine experts participated in the meeting, representing Laboratoire d'hydrogéologie, Université d'Avignon et des Pays du Vaucluse (LHA, France), the US Geological Survey (USGS, USA), the Federal Institute for Geosciences and Natural Resources in Germany (BGR, Germany), the International Association of Hydrogeologists (IAH, UK), the World Meteorological Organization (WMO, Switzerland), the Geological Survey of Slovenia (GeoZS, Slovenia), and the IAEA. Each expert presented a brief overview of their organizational mission, structure, and programme activities related to water resources assessment. IAEA experts presented the motivation behind the Water Availability Enhancement Project, its anticipated structure, plans for pilot studies, and the importance and mutual benefit of partnerships.

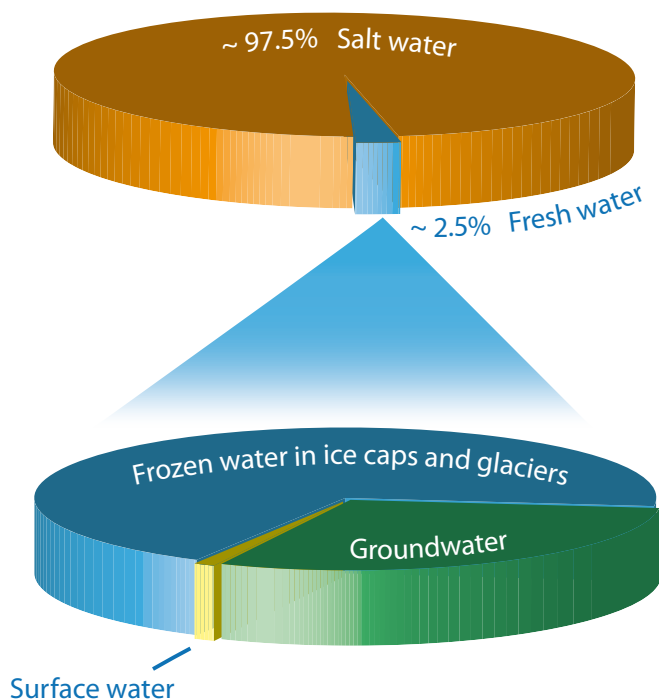
Valuable comments were made on how to use existing technological support within the hydrological community, including experts and training. The consultants also discussed the possible role and contribution of other partners in implementing the Water Availability Enhancement



*Local drilling in Chapai, Bangladesh. Many countries struggle to find enough potable water for their population, and water stress is predicted to grow. (Photo credit: IAEA).*



## ALL WATER ON EARTH



*Distribution of fresh water available for use [2].*

Project. A primary outcome of the Consultants Meeting is the Recommended Action that the IAEA Water Resources Programme, together with interested partners, conduct pilot studies with selected countries.

### Pilot Studies

The pilot phase of the Water Availability Enhancement Project will be conducted over the next 12 to 18 months. In each pilot study the IAEA will lead collaboration with the selected country to identify and characterize gaps in national water resources assessment, and to develop a work programme aimed at strengthening local capacity to address the gaps. Elements of the work programme will be met through IAEA's own resources and by utilizing collective expertise, as well as the technological and infrastructure support of new and existing partners within the international hydrological community.

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*Beginning with a pilot effort in 2010, the IWAVE Programme is expected to support an expanding portfolio of national assessments.*

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It is anticipated that technical assistance programmes will provide training on topics such as:

- Database development and management for hydrogeological and other key data;
- Groundwater resource mapping, including identification of recharge zones;
- Water use analysis and draw down modelling;
- Water quality analysis and modelling;



*In many arid parts of the world, groundwater is the main source of potable water (Photo credit: IAEA).*



*The IAEA organized a Consultants Meeting, from 4–6 May 2010, in Vienna. The meeting included several experts, and was conducted to provide an opportunity for participants to discuss the programme concept and search for possible partners.*

- Conceptual modelling of surface/groundwater interactions, characteristics and movement;
- Vulnerability evaluation, including identification of soil/groundwater contamination threats;
- Artificial recharge techniques and options development;
- Cost/benefit analyses of competing water uses.

Where isotopic techniques are involved, the IAEA Isotope Hydrology Section will have a primary responsibility in providing support and training. Isotope techniques are commonly employed in hydrological studies to investigate:

- Groundwater recharge sources and mechanisms;
- Groundwater age;
- The rate of groundwater movement;
- Mixing between adjacent aquifers, and interaction between surface and groundwater;
- The relation between rainfall, runoff in streams and rivers, and flooding and sedimentation.

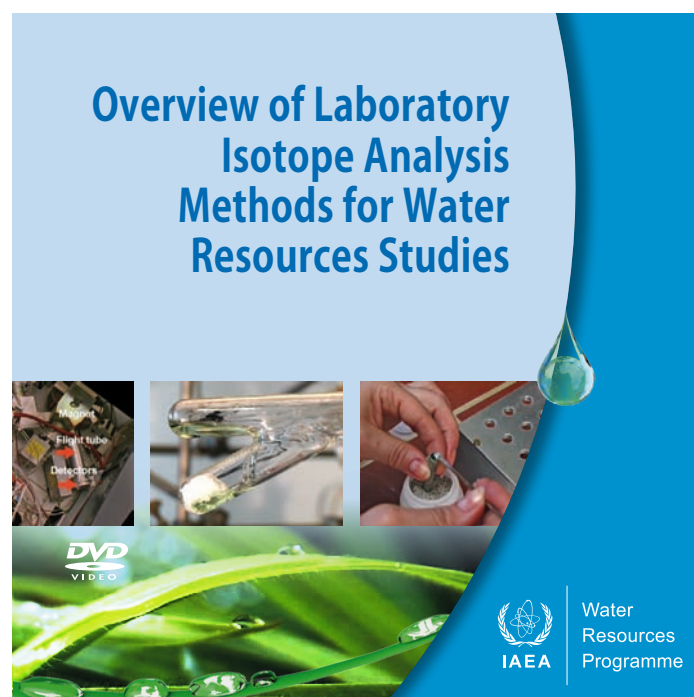
A successful Water Availability Enhancement pilot study will provide enhanced water availability as a direct result of increased hydrological expertise and technological capabilities of a Member State. The project will strengthen the Member State's capacity to develop and periodically update water resource assessments, and to design and implement resource management strategies.

These pilot studies are the foundation for expanding the Water Availability Enhancement Project to interested countries across all continents. Beginning in 2010 with the pilot studies, the Water Availability Enhancement Project is expected to support an expanding portfolio of national projects in partnership with national ministries and research institutes, water resource agencies, and basin management organizations.

## Reference

- [1] UNITED NATIONS, Water Development and Management, Proc. United Nations Water Conference, Mar del Plata, Argentina, March 1977, Part 1, 1978, Pergamon Press, p. 273.
- [2] SHIKLOMANOV, I., "World fresh water resources" in: Water in Crisis: A Guide to the World's Fresh Water Resources (Ed: GLEICK, P.) (1993) Oxford University Press, New York.

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*The Isotope Hydrology Section will soon release a new DVD, which will provide an overview of laboratory methods used for preparation and analysis of samples for deuterium and oxygen-18, carbon-13 and carbon-14, noble gases, tritium, and CFCs. Many details are covered and individual methods can be reviewed to gain a better understanding of how to conduct isotope analyses in the laboratory.*



# Water Balance Modelling of the Nile River System to Aid in Understanding Hydrologic Interactions

By P. Gremillion, Z. Kassa (IAEA)

*The role of groundwater in the Nile Basin is increasingly important for Nile Basin countries, but although researchers have long studied various aspects of the basin, the relative influence of groundwater has not received much attention.*



Map of the Nile Basin showing river gauging stations and meteorological stations. The IAEA is gathering an unprecedented amount of data on the Nile Basin.

The importance of understanding the hydrology of the Nile Basin cannot be overstated. In this massive watershed, the interests of providing Nile countries with an adequate water supply competes with the need to protect unique and irreplaceable ecosystems like Lake Victoria and Lake Tana, the Equatorial lakes, and the Sudd swamp. Researchers worldwide have long studied various aspects of Nile Basin hydrology, from rainfall studies in the Ethiopian highlands to evaporation rates in Lake Nasser. An important aspect of the basin's hydrological cycle that has received less attention, however, has been the relative influence of groundwater in the basin.

Groundwater plays an increasingly important role for Nile Basin countries. It is the source of water for irrigation and other uses in many parts of the basin; in some countries it provides large percentages of the urban water supply. Additionally, groundwater use is expected to increase significantly in the next decade, as is its vulnerability to pollution. However, limited information exists on the quantity and movement of groundwater in the Nile countries, particularly in relation to rivers, lakes, and wetlands — the surface waters — of the Nile system.

A highly effective strategy for understanding interactions between surface water and groundwater is the use of water balance models. In their simplest form, water balances account for all the inputs and outputs of water in a given system, such as rainfall, evaporation, river flow, recharge to groundwater aquifers, and discharge

of groundwater. Water balance models can be conducted on a variety of scales, from small headwater catchments to continental scale systems, such as the entire Nile Basin.

The Isotope Hydrology Section is working with Nile countries on a project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Development Programme (UNDP), entitled, 'Mainstreaming Groundwater Considerations into the Integrated Management of the Nile River Basin'. This project works towards assisting Nile countries in management of rivers, lakes, and wetlands by conducting water balance studies to evaluate the relative influence of groundwater.

The IAEA/UNDEP/GEF Medium Size Project (MSP) entitled 'Mainstreaming Groundwater Considerations into the Integrated Management of the Nile River Basin (RAF8042)' was initiated at a meeting held in Vienna in May 2006 on 'Sustainable Development and Equitable Utilization of the Common Nile Basin Water Resource (RAF8037)'. In November 2006, the IAEA Board of Governors approved the project. Two years later, a project inception meeting was organized by the IAEA, as executing agency of the MSP, in Vienna from 27 to 30 January 2009. With the objective of reviewing existing work and refining the project work plan, the first coordination meeting was held in Nairobi in August 2009.

The countries involved in the project are: Burundi, Democratic Republic of the Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, United Republic of Tanzania, and Uganda. Major components of the project are:

- Assessment of the interaction between major tributaries of the Nile River and groundwater;
- Assessment of the interaction between wetlands and

groundwater;

- Integration of isotope data into water balance models;
- Sub-basin and basin wide water balance modelling.

## Data Collection

Water-balance modelling integrates nearly every form of water quantity data. This project will permit the IAEA to compile an unprecedented library of data on the hydrology of the Nile Basin.

Water-balance models will use satellite derived daily estimates of precipitation and evapotranspiration in a GIS grid to model stream flow components in the basin. These data are available in almost real time. The value of the model in accurately simulating the water balance is increased by calibrating the model to as many high quality historical data as possible. These data can be obtained through cooperation with national hydrological and meteorological organizations in each

project member country.

Large climatic and river discharge time series data sets have been collected from various web based global databases: Major data repositories from where data have been collected are: Global Runoff Data Centre (GRDC), Global Precipitation Climatology Centre (GPCC), Food and Agriculture Organization (FAO), US Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA).

Data collected from these varied sources will pass through a process of statistical treatment, validation and preparation of data in a consistent model format. In addition, field campaigns are underway or are being planned for all project

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*As a part of the project, the IAEA will help compile an unprecedented library of data on the hydrology of the Nile Basin.*

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*Wetlands in Egypt. Many countries are dependent on Nile waters for survival (Photo credit: Nile Basin Initiative).*



member countries. Groundwater, river, lake, and rain water will be collected and analysed for the water isotopes deuterium, tritium and oxygen-18 ( $^2\text{H}$ ,  $^3\text{H}$ , and  $^{18}\text{O}$ ). These data will drive the isotopic component of the final USGS Precipitation and Runoff Simulation Modelling System (PRMS) model.

## The Water Balance Model

Water balances will be conducted using a surface–water modelling system modified to include a groundwater component estimated through stable isotopes of water. A version of PRMS coupling hydrologic and isotopic data to estimate base flows is being developed by George Leavesley, formerly at USGS and currently with Colorado State University. Although PRMS was designed to model surface waters, the inclusion of isotopic data elicits the capability to estimate magnitudes of groundwater interaction.

PRMS simulates spatial and temporal distribution of groundwater recharge and discharge, but the groundwater component is treated simply as a spatially distributed set of linear reservoirs. Isotope data will provide the capability to improve simulated magnitudes and timing of groundwater recharge and discharge. In addition, PRMS has recently been fully coupled with the USGS groundwater model MODFLOW, in a new modelling package called GSFLOW. Calibrated parameters for PRMS could be used directly in GSFLOW which would provide additional opportunities to examine surface water–groundwater interactions in more detail on selected Nile sub-basins.

The model will be tested and validated with lake data from Shingobee Basin in Minnesota, United States of America. This version of PRMS will include the Priestly–Taylor equation as part of the capability to estimate evapotranspiration and detailed flux and momentum equations for lake mixing components. This is possible because of the detailed data sets available for the Shingobee Basin. However, for more general applications, where such data are limited or not available, it may be necessary to simplify assumptions or to use more basic equations.

Modelling of the Nile system will first focus on small sub-basins such as Lake Victoria and Lake Tana in the Ethiopian highland. After testing and validating the sub-basin models, a basin wide water balance model of the Nile basin will be developed.

## Project Partners and Outcomes

This project directly supports water management activities in the water agencies of each participating government. In addition, this project is being conducted with the cooperation of the Nile Basin Water Resources Planning

and Management (WRPM) project within the Nile Basin Initiative (NBI). Some specific outcomes will be:

- Water balances for major Nile tributaries, Lakes Tana, Victoria, Edward, and Kyoga, as well as the Sudd and other major Nile wetlands;
- Increased capacity in isotope hydrology and water balance modelling;
- A calibrated basin wide water balance model;
- A comprehensive database of climatologic, discharge, and isotopic data for the Nile Basin.

## Upcoming Activities

### 1. Coordination and Steering Committee Meetings

Project coordination and steering committee meetings will be conducted on the NBI premises in Addis Ababa during 28 September–01 Oct 2010. The purpose of the meetings is to evaluate progress of the project and discuss the next steps. Twenty-four participants from Nile basin countries, the NBI, the IAEA and international experts are expected to participate in the Addis Ababa meetings next September.

### 2. Regional Training Workshop on Basic Isotope Hydrology

A two week regional training workshop on Basic Isotope Hydrology will be conducted in Kampala, Uganda from 15–26 Nov 2010. The training course is open to 21 participants from project member countries in the Nile basin.

### 3. Regional Training Workshop on Water-Balance Modelling

Another regional training workshop on Integration of Isotope Data in River Basin Water-Balance Models will be conducted in Egypt at the Groundwater Research Institute from 29 Nov–10 Dec 2010. The course is open to 20 participants from project member countries and the NBI.

*For further information contact P. Gremillion at [p.gremillion@iaea.org](mailto:p.gremillion@iaea.org)*



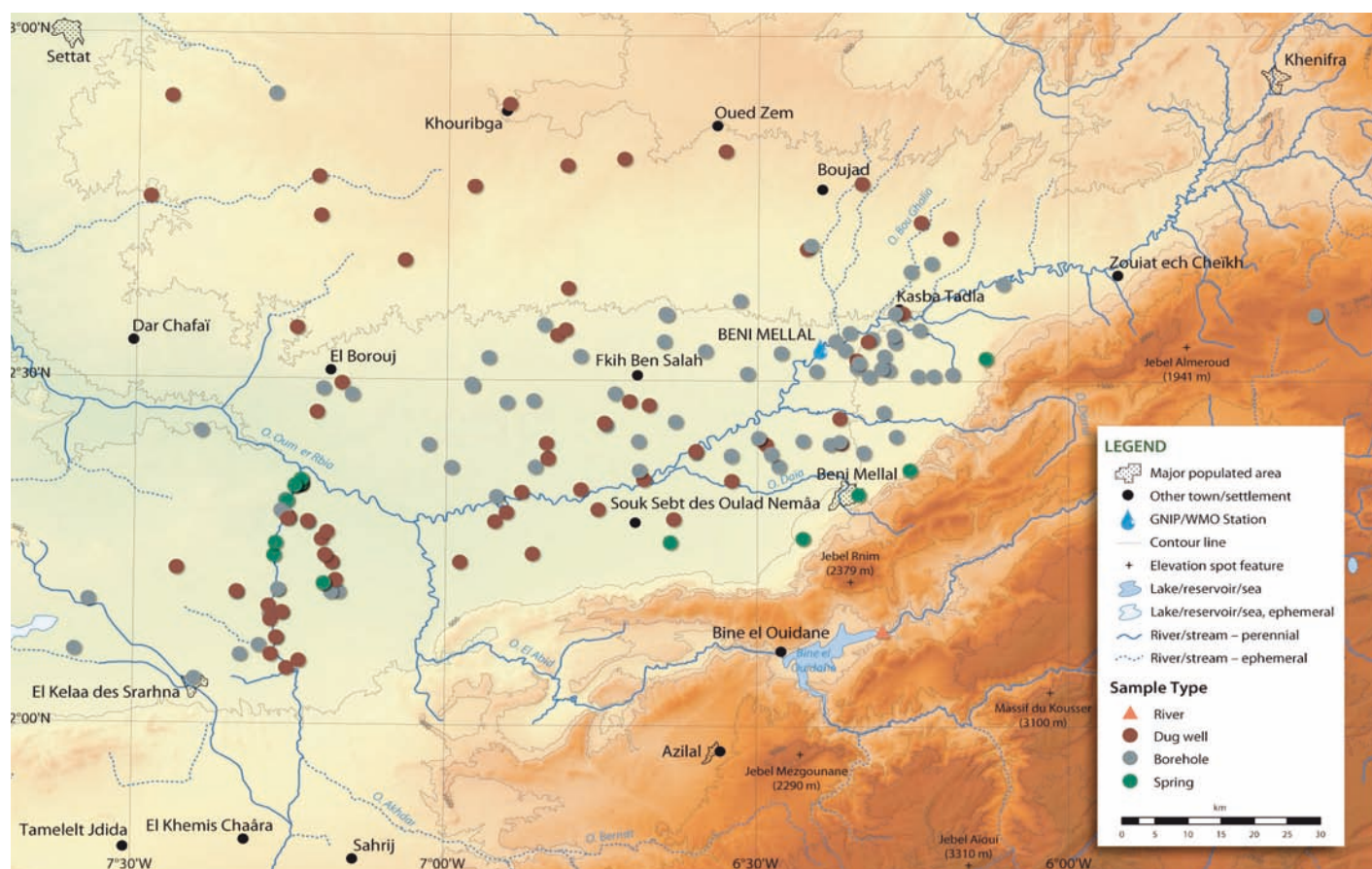
*Surface and groundwater interactions in the Nile Basin are currently poorly understood (Photo credit: Nile Basin Initiative).*



# Improving Understanding of Hydrogeology in Morocco's Tadla Basin

By H. Marah, M. Qurtobi, N. Zine, A. Zeouali (National Centre of Nuclear Energy, Sciences and Technology (CNESTEN), State Secretary in charge of Water and Environment of Morocco),  
B. Newman, P. Aggarwal, S. Terzer (IAEA)

*Sample data and maps have been produced from the Tadla Basin project which can serve as an example for similar projects undertaken in other aquifers around the world.*



Map of sampling points within the Tadla basin.

The Tadla Basin — situated in the center of Morocco — is an important agricultural area, and the demand for groundwater is greatly increasing. Groundwater provides the majority of freshwater supply for basin cities and is derived from a multi-layered aquifer system. This aquifer system was the subject of an earlier project undertaken by the IAEA, CNESTEN and Moroccan water authority. Important relationships between aquifer layers and locations of recharge and discharge were revealed during this study. Supplementary spatial analyses of isotopes in the Turonian, Eocene, and Quaternary aquifers of the Tadla Basin were subsequently used to develop visual means of identifying hydrological trends.

The basin consists of three geographical units: the Plateau des phosphates, the Tadla Plain and the Tassaout avale. The basin area — crossed by the Oum Erbia River — is about 10 000 km<sup>2</sup>, and the average annual rainfall is about

550 mm. The Tadla Plain, which has been most heavily investigated, has four aquifers (Mio-Plio-Quaternary, Eocene, Senonian, and Turonian) which are separated by semi-permeable horizons. Previous isotope work confirmed that these horizons can allow hydrological mixing between the aquifers, and that some mixing is indeed occurring.

The objectives of isotope investigations in the Tadla Basin were to provide a better understanding of hydraulic conditions in the basin and quantify hydrologic characteristics in order to provide confirmation of observations obtained using traditional hydrological investigations, provide a better model simulation of groundwater dynamics, and optimize resource management for the Tadla Plain.

During the original study, 184 groundwater samples were collected in the course of two IAEA projects between 1999–2002 from unconfined and confined areas of the

Mio-Plio-Quaternary, Eocene, and Turonian aquifers, springs, surface water and basin precipitation, and analysed for their chemical and isotopic composition. The map on p. 9 is a physiographic map of the area, including sampling locations and water types.

## Spatial Aquifer Analyses

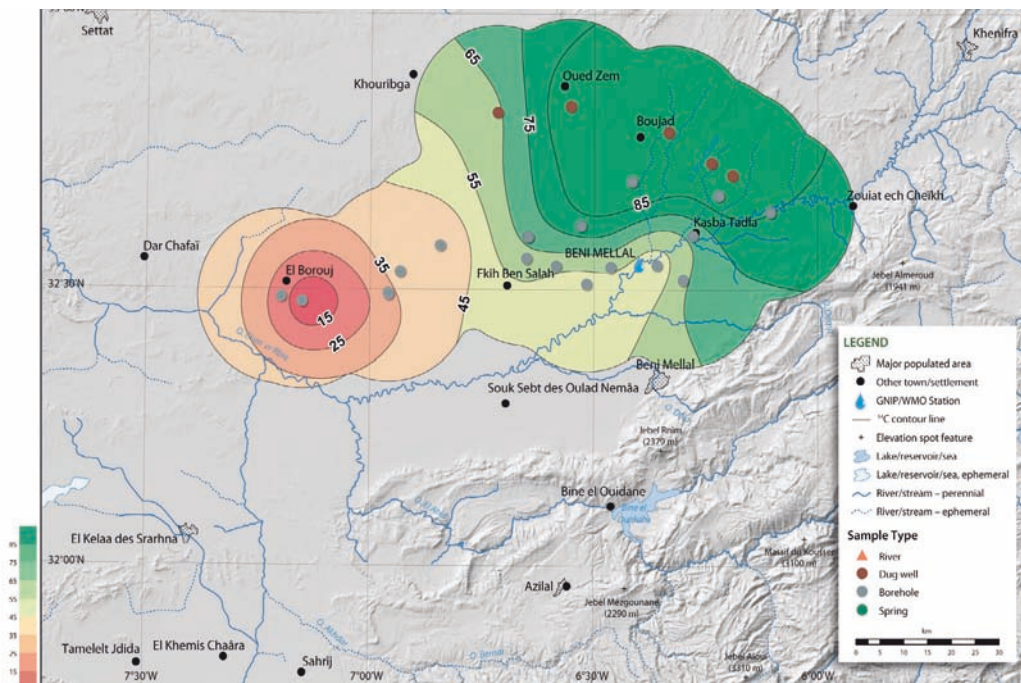
Interpolation maps were generated for oxygen-18, tritium, and carbon-14 for the Turonian, Eocene, and Mio-Plio-Quaternary aquifers. These interpolations aid in visualizing trends across the basin within a given aquifer and illustrate differences between the aquifers.

The most important water supply in the basin is derived from the Turonian aquifer. Carbon-14 interpolation (map below) shows a high percent of Modern Carbon (pMC),

reflecting recent recharge in the northeast compared to the west side of the basin. Turonian tritium interpolation (not shown) follows a similar trend. Carbon-14 and tritium interpolations also show that the confined aquifer zone in the west is characterized by older water (with low pmc and low tritium). These interpolations highlight that recharge is greatest in the northeast and indicate a dominant groundwater flow trend from northeast to southwest.

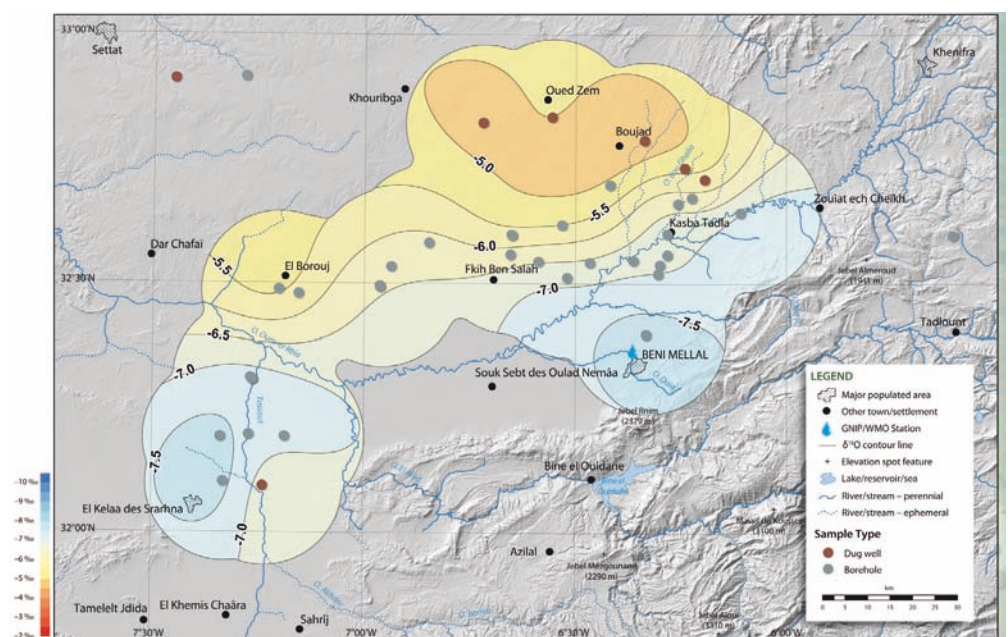
Oxygen-18 interpolation for the Turonian also exhibits strong differences across the basin (map below). The effect of high elevation recharge is clearly shown by more negative isotope values along the southern border with the high Atlas Mountains/Tassout area compared to more northern parts of the basin.

Quaternary aquifer oxygen-18 interpolation (above) also shows differences across the basin, although they shift in an

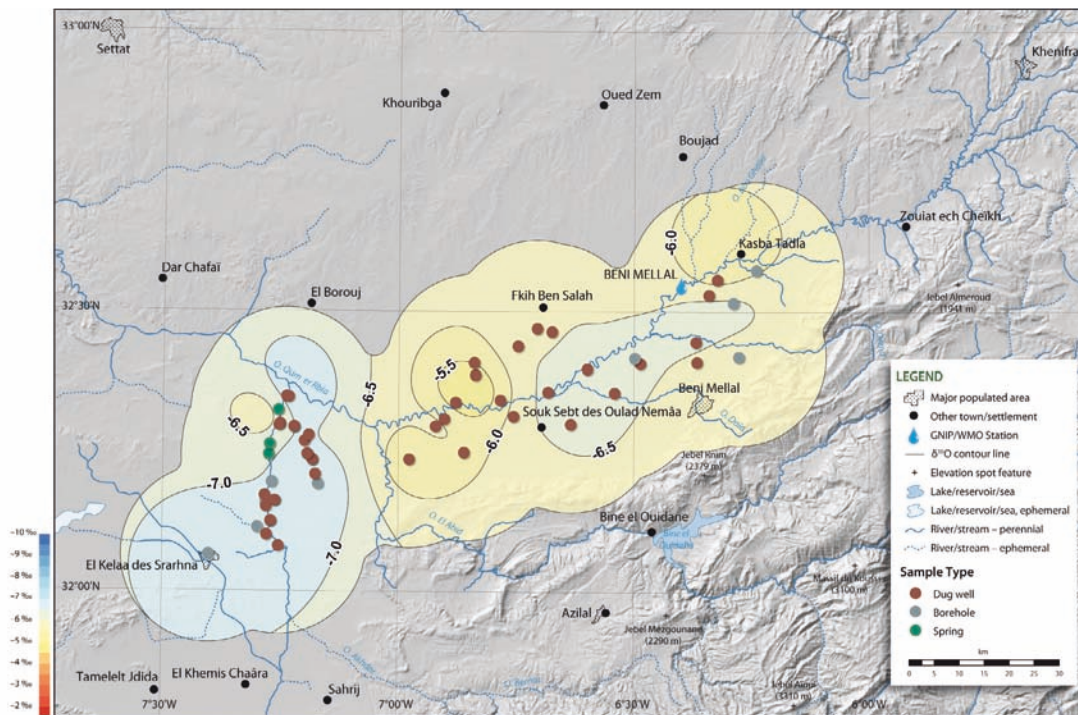


*Turonian aquifer  $^{14}\text{C}$  interpolation; units in pMC.*

*Turonian aquifer oxygen-18 interpolation; units in per mil (‰).*







*Mio-Plio-Quaternary aquifer oxygen-18 interpolation; units in per mille (‰).*

east/west direction compared to the north/south direction in the Turonian aquifer.

The more negative oxygen-18 values in the west reflect high elevation recharge. Another important aspect of this western area is the source of water to the Tassout Springs. Stable isotope differences suggest that the deeper aquifers of the Tadla are not supplying water to the springs, which was an earlier hypothesis.

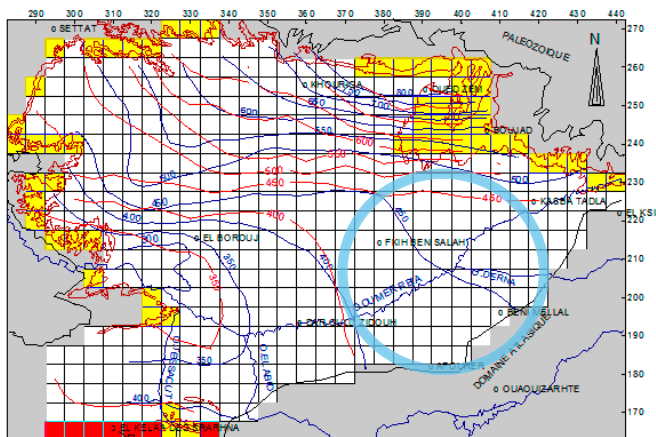
These are just a few examples of the importance of understanding the spatial distribution of isotopes at the basin scale. Such maps can be a great aid in interpreting isotope data and are a simple way of showing others who do not have an isotope background what isotopes are indicating.

## Study Impact on Tadla Basin Management

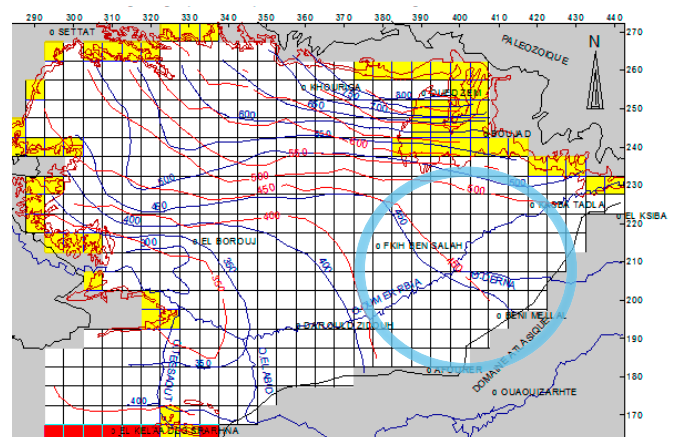
Integration of the isotope results from this work has helped to develop an improved version of the hydrologic flow model, which can be used for management purposes. Tadla isotope results were used to refine permeability estimates in the basin flow model for the southeast part of the basin. A reduction in permeability was required for model results to be consistent with isotope results, and this yielded an improved calibration of the mathematical model of basin flow and transport (maps below). Thus, isotopes have been directly used to improve groundwater resource management in the Tadla Plain.

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### Initial model



### Using isotope constraints



*These maps show improved agreement between observed piezometric contours (in black) and modelled contours (in red) after model parameters were adjusted based on carbon-14 results.*

# Getting the Word Out at the EGU

By M. MacNeill (IAEA)

*The Isotope Hydrology Section participated in presentations and poster sessions as well as having a booth at the European Geosciences Union General Assembly.*

The Water Resources Programme transferred information about the science of isotope hydrology and ongoing projects of the Isotope Hydrology Section at the 2010 European Geosciences Union (EGU), held at the Austria Center from 3–7 May.

A full house was on hand for a presentation made by Section Head Pradeep Aggarwal, who lectured on ‘Better Characterization of Young and Old Groundwater Systems Through Improved Groundwater Dating by Isotope Methods’, during which he discussed the benefits of proper groundwater dating while highlighting the risks of not defining this resource.

*Nearly 10 500 scientists were in attendance, many of whom visited the Water Resources Programme booth.*

Over-extraction can lead to decreased baseflow in rivers, destruction of wetlands, a reduction in water quality, and marked lowering of the water table. A clear understanding of hydrological conditions is necessary to ensure rational management and sustainable withdrawal of these resources.

The presentation included information about what types of isotopes are used by the IAEA in the dating of groundwater, including the tritium–helium-3 dating technique for recently recharged groundwater, and radioactive tracers such as carbon-14, chlorine-36 and krypton-81 for groundwater with a longer residence time.

A presentation entitled ‘Examination of Global River Systems Using Stable Isotope Methods’ and delivered by Brent Newman of the Isotope Hydrology Section, was also well attended. The subject of the presentation was the Global Network of Isotopes in Rivers (GNIR), a recent compilation of stable isotope data from rivers around the world; this compilation now makes an initial global comparison of river isotope data feasible. The information available in GNIR shows definite trends, such as latitude effects and strong links between river waters and precipitation. The great variation in captured data reflects the large differences in global climate conditions. A theme currently being examined by the Section is how river isotope distributions can be used to understand a given river’s relationship to precipitation inputs and/or degree of processing within a basin. Figures from selected rivers were used to show the effects of seasonality and changes affected in course flow



*Many participants gathered information and asked questions at the IAEA booth.*

by manmade constructions, such as dams or reservoirs.

Many attendees of the conference came to see the Section’s poster presentation entitled ‘Long-term Tritium Monitoring to Study River Basin Dynamics: Case of the Danube River Basin’, and ask questions about the information. The poster described how the IAEA has recently started compiling new and archival isotope data measured in groundwater, rivers, lakes and other water bodies as part of its web based application Water Isotope System for Data Analysis, Visualization and Electronic Retrieval (WISER). WISER is being used to process GNIR information, making detailed river studies possible. Residence time estimates for the Danube in central Europe were re-examined in the highlighted study. Most of the 15 monitoring sites along the Danube have been continuously collecting tritium records for over 10 years, with the longest running and most



*The Water Resources Programme displayed atlases and other materials at the European Geoscience Union's General Assembly.*



complete record set coming from Vienna and running back to the 1960s. The IAEA is currently re-evaluating upper Danube residence time using a complete record covering the entire tritium transient created by atmospheric nuclear weapons testing (1964–2005). Models assume that there is a ‘fast’ component, representing water with a short residence time, and a ‘slow’ component, representing discharge of older groundwaters to the river. Preliminary results were presented, showing new insights into the age distribution of water in the upper Danube, and initial calculations from the Vienna records, which suggest that mean residence time is much greater than previously thought.

The Water Resources Programme disseminated information about the latest developments in isotope hydrology at a booth which displayed posters — including one on recent

work undertaken at the Nubian Sandstone Aquifer — along with atlases of isotope hydrology, part of a series being published by the IAEA. Visitors were very interested in material made available by the section at its stand, including CDs, DVDs, postcards, bookmarks, newsletters, pamphlets and books.

The EGU — the second largest association of geoscientists — provides an opportunity for specialists and students from around the world to exchange information and find out about the latest developments in their fields at its annual General Assembly. The 2010 gathering was considered to be a great success, with 4431 oral and 9370 poster presentations in 594 sessions. There were 10 463 scientists from 94 countries participating, about a quarter of which were students.

## Reader's Corner

Dear readers of the IAEA isotope hydrology newsletter,

We would like to improve our communication with the isotope hydrology community, and in general with all those using isotope techniques in geochemistry and Earth Sciences. To reach this objective, we would like to start a column for questions and feedback in our newsletter.

We would like to open this to the following:

- Requests for information on past, present, and future IAEA programmes in our field of activity (coordinated research programmes, technical cooperation programmes, research, advisory and consultant group meetings, training courses, intercalibration exercises, publications, etc.);
- Suggestions for future programmes and activities;
- Expounding on technical and scientific aspects which may stimulate discussion and exchange of

information among readers;

- Information for readers on current and planned activities in institutes, laboratories and organizations working in isotope hydrology and related fields;
- Illustrations of any other technical and scientific matters which may be of interest to our readers.

E-mails should be addressed to: [M.Macneill@iaea.org](mailto:M.Macneill@iaea.org)

Please be concise and address issues of general interest. We will publish a selection of received mails together with replies (when applicable).

We hope that this new initiative will encourage our readers to take an active interest in isotope hydrology.

Pradeep Aggarwal, Head, Isotope Hydrology Section, Division of Physical and Chemical Sciences, International Atomic Energy Agency, Vienna, Austria

# Isotope Mapping Methods Examined



*Participants of a five day Research Coordination Meeting on using geostatistical methods, mapping and visualization tools to interpolate isotope data.*

A third and final Research Coordination Meeting (RCM) was held in Vienna from 15–19 March to discuss the outcome of an IAEA Coordinated Research Project (CRP) on how to use geostatistical methods, mapping, and visualization tools representing temporal and spatial distribution of hydrochemical and isotope data to improve the capability and efficiency of environmental isotopes in assessing water resources in Member States.

Over the last few decades, water isotopes have been extensively used to address key aspects of the water cycle, such as study of the origin, dynamics and interconnections of different elements of the hydrologic cycle. In recent years, the use of isotopes as tracers of the water molecule and solutes has been extended beyond the classical applications of isotope hydrology to other scientific disciplines, ranging from atmospheric circulation processes to palaeoclimatology or ecology, fields in which isotopes have been recognized as powerful tracers to better characterize hydrological and environmental systems and processes. Outcomes of the CRP include:

- Significant improvements to both the collection of precipitation samples and methodology for producing precipitation isotope maps;
- Consensus that the best methodology for producing precipitation input functions is to develop gridded weighted mean annual maps using the methodology of Bowen and Wilkinson;
- Realization that surface water isotope compositions

have identified differences in source water compared to precipitation;

- Results showing that spatial distribution of water ages has proven very useful for water resource management;
- Employment of various software programmes in the spatial mapping of isotope data (Surfer, ARCGIS, etc.);
- Maps which highlight regions where more data are needed to fill in missing areas and validate existing maps;
- Greater accessibility of isotope data through mapping for water resource managers;
- Increased interaction between regional participants.

The objectives of the different participants in the CRP included: compilation of isotope datasets with associated hydrochemical and hydrological information for application in the fields of climatology, hydrology, and water resource management; application of geostatistical methods and mapping and visualization tools to integrate hydrological, hydrochemical and isotope data; evaluation of the potential and limitations of these techniques for routine applications including environmental isotopes, and; development of thematic maps based on isotope and related data of hydrological variables relevant to the evaluation and assessment of hydrological and climatological variability and its relevance for water resources assessment and management.

In the future, an IAEA-TECDOC will be published on this CRP and software will be made available on the internet for interpolation of stable isotope data for mapping.

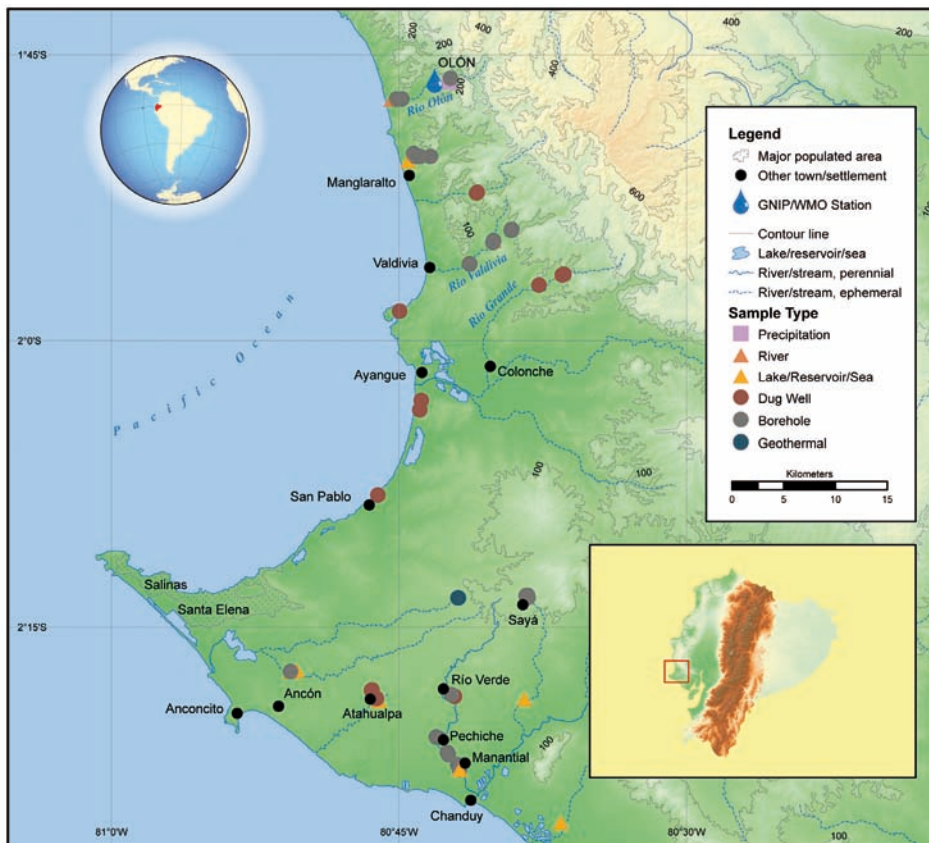


# Ecuadorian Aquifer Studied for Marine Intrusion

By S. Jiménez Oyola; P. Carrión Mero; P. Romero Crespo

Grupo de Investigación CIPA-CT, Escuela Superior Politécnica del Litoral (ESPOL)

*Dissemination of project results will ensure that the conceptual model of the aquifer is shared with decision makers, who can then incorporate it into policy and water management plans.*



*Map of the Santa Elena peninsula with sampling points.*

In 2007, a Technical Cooperation Project called 'Characterization of Coastal Aquifers on the Santa Elena Peninsula' (ECU8026) was launched to better assess groundwater resources in the area and investigate whether aquifers in the Santa Elena area of southwestern Ecuador (see map above) are affected by marine intrusion.

The Escuela Superior Politécnica del Litoral (ESPOL), Guayaquil, Ecuador, implemented the project in collaboration with other local institutes to uncover the impact of marine intrusion, if it exists, on the sustainability of this crucial water resource. Groundwater constitutes the main source of drinking water in the area, complemented by surface water resources derived from the Santa Elena reservoir, for the local population and approximately 80 000 tourists. Due to the semi-arid climate of the area, affected by the relatively cold Humboldt stream, the coastal zones are facing important deficits in fresh groundwater, surface water and vegetation. The traditional rural water supply based on shallow dug wells and rainwater infiltration ponds (locally known as albarradas) has therefore been gradually

complemented by deeper boreholes. However, intensive pumping during the past decade has led to lowering water tables and an increase in salinity, leading to the abandonment of several boreholes. Dryness is particularly pronounced in the southern zone of the Santa Elena peninsula around the city of Salinas, where mean annual rainfall amount is only 112 mm, distributed between January and April, mean annual temperatures range between 17°C and 35°C, and mean annual potential evapotranspiration is higher than 1200 mm. In the peninsula's northern zone, the phenomenon of 'garuas' (low fog and drizzling rain) may account for a slightly more humid environment.

## Hydrogeological Settings

The principal coastal aquifer of the Santa Elena peninsula consists of the Tablazo formation, composed of Quaternary sandstones and conglomerates, covered by alluvial river deposits formed by unconsolidated sands, gravels and clays, and underlain by the impermeable Azúcar formation. The

unconfined alluvial sediments correspond to groundwater recharge zones and supply drinking water to northern zone communities (Olón, Manglaralto, Valdivia) through shallow wells within or near the river bed. More pronounced stream/aquifer connections exist in the southern zone (río Verde, Pechiche, Manantial, Atahualpa), where groundwaters are recharged by streams and vice versa.

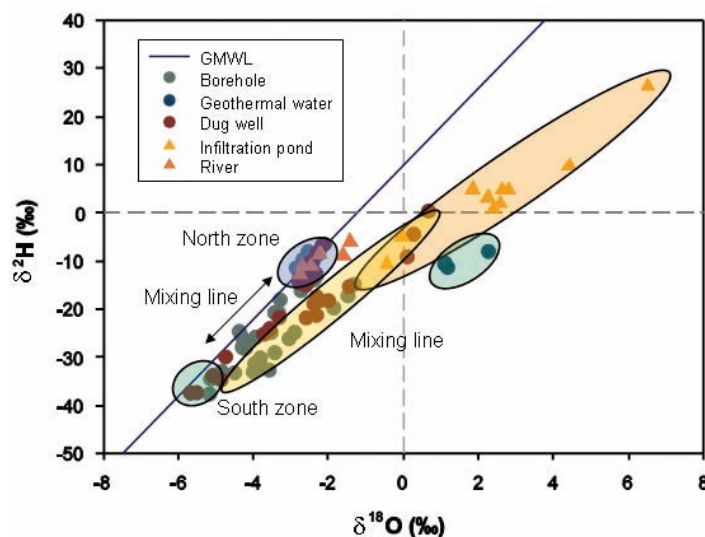
## Hydrochemistry and Isotopes

Three sampling campaigns for hydrochemistry and isotope parameters in groundwaters were carried out over the last two years under Technical Cooperation Project ECU8026, involving rainfall, surface waters, and groundwaters of

*Elevated salinity in some samples within the Tablazo formation is accounted for by marine origin of the sediments; no marine intrusion has been detected at the examined sites.*

both the northern and southern zones of the Santa Elena peninsula. New hydrological and geochemical data have contributed to the development of a conceptual hydrogeological model of the area, illustrated by stable isotope data (figure top right). The Santa Elena area aquifers consists mainly of rapidly recharged waters of

short residence times, resulting in a very dry southern zone, with particularly isotopically depleted precipitation between January and March. These isotopically lighter groundwaters are mixed along the Meteoric Water Line with groundwaters from the northern zone Tablazo formation aquifer, and along an evaporation line with groundwaters



*Isotopic characterization of principal water types and their interactions in the Santa Elena aquifer.*

derived from water accumulated in infiltration ponds called 'albarradas' in the southern zone. Geothermal springs in the southern zone are indicated through pronounced deviations in oxygen-18 values. Elevated salinity in some samples within the Tablazo formation aquifer is accounted for by the marine origin of sediments; no marine intrusion has been detected at the examined sites. However, rapid infiltration and mixing within both Tablazo and alluvial formations may impact on potential contamination pathways and vulnerability of the aquifer.

## Regional Impact of Results

Regional water communities and services have been involved in sampling, field monitoring (see picture left) and educational activities, such as individual fellowships and participation in a national training course in Guayaquil in November 2009. In addition, the main counterpart institute ESPOL (Escuela Politecnica del Litoral) has organized 11 meetings and fieldtrips. The most important one, in October 2009, included the National Water Agency (Secretaria Nacional del Agua SENAGUA), the Ministry of Regional Development (Ministerio del Desarrollo Urbano y Vivienda MIDUVI) and regional and municipal organizations. Thorough dissemination of project results will ensure that the conceptual model of the Santa Elena area aquifers is shared with decision makers, who can adopt it in future water management plans.



*Regional water communities and services have been involved in sampling, field monitoring and educational activities (photo credit: IAEA).*

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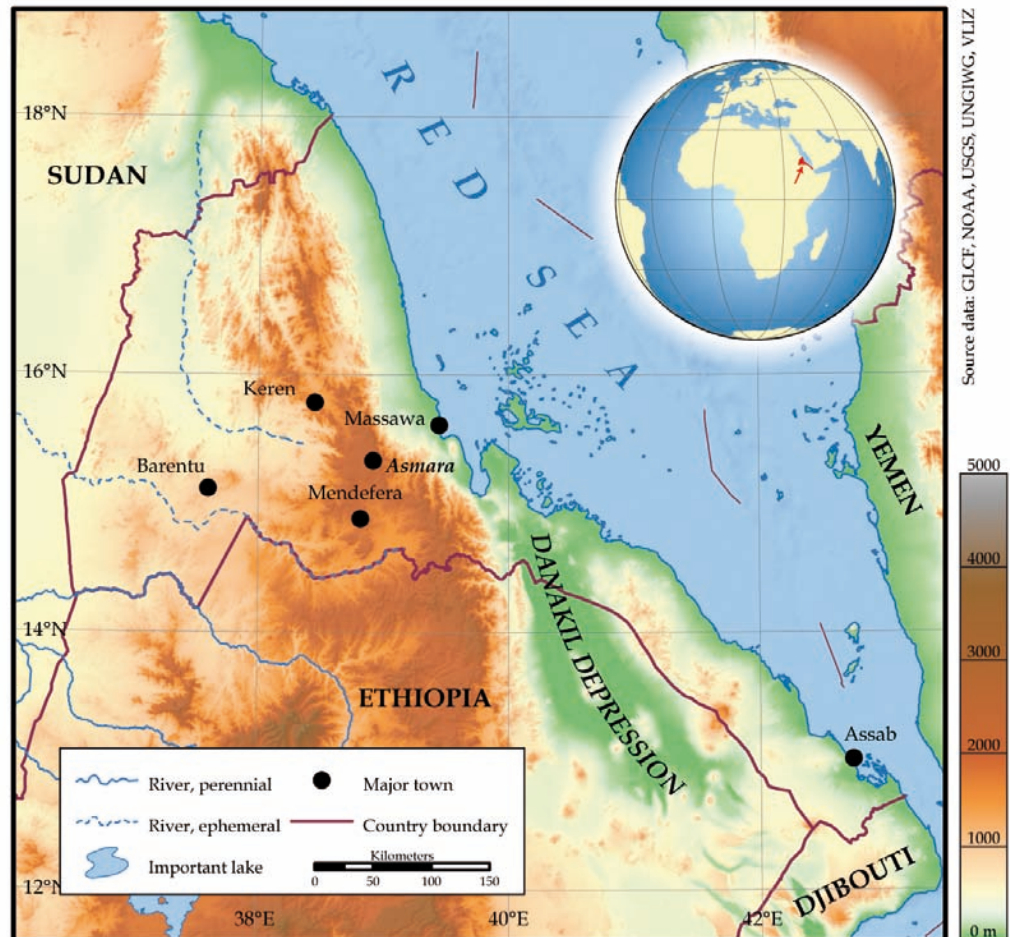


# Defining Eritrea's Scarce Water Supply

By T. Keleta, S. Berhe, M. Aregai, Ministry of Land, Water and Environment, Department of Water Resources Asmara, Eritrea, H. Marah, CNESTEN, Rabat, Morocco, and M. Ito (IAEA)

*Results suggest that elevated salinity in groundwater is not likely due to the intrusion of seawater, but is probably resulting from evaporation together with mixing with brackish water from deep aquifers.*

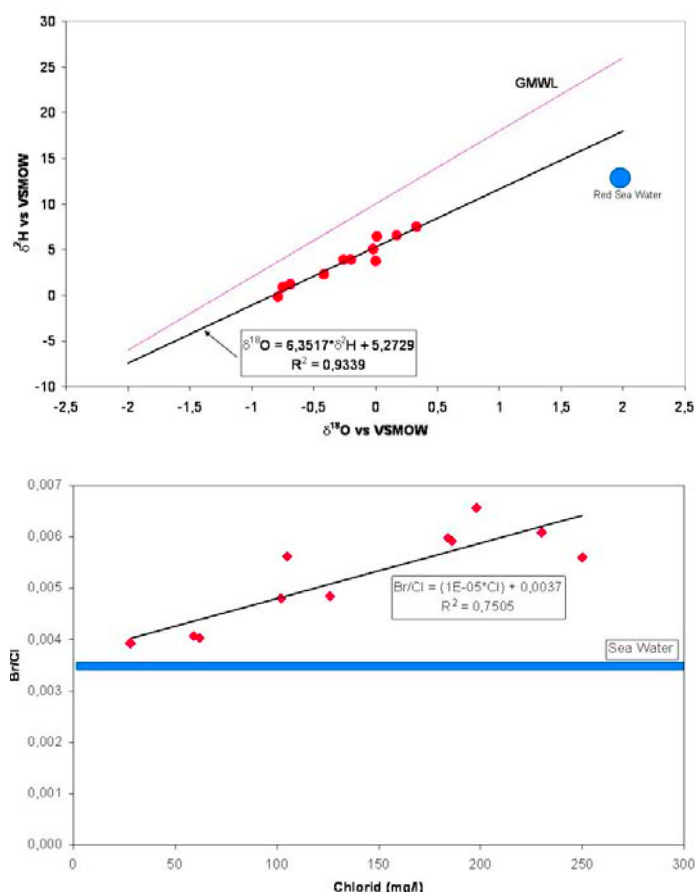
Location map of Eritrea.



Eritrea — located in Northeast Africa — covers a surface area of 117 600 km<sup>2</sup>. The country has a long stretch of coastline along the Red Sea to the northeast, across from which are Saudi Arabia and Yemen. Sudan is to the west, Ethiopia to the south and Djibouti to the southeast (above figure). The Red Sea region, with its multiple ports, especially the major ports of Assab and Massawa, is economically vital to the country. Part of the East African Rift System, the area also has high potential for geothermal energy development and mineral water exploitation. Sustainable water management is regarded as a priority in this region, as it is a major basis for socio-economic development. The main aquifers in the area are primarily located in Quaternary alluvial deposits and vesicular basalt flows originating from volcano massifs.

Two national technical cooperation projects in isotope hydrology were started respectively in 2007 and 2009 by

the Department of Water Resources, the Eritrean Ministry of Land, Water and Environment and the Ministry of Health. These projects aim to contribute to improving the potable water supply in the region by determining whether aquifers are affected by salt intrusion into the Eritrean part of the Red Sea Basin, which extends from the northern Gulf of Suez southeast along the Red Sea to the Gulf of Aden in the Indian Ocean. 'Isotope Hydrology in the Red Sea Basin' (ERI8002) is the first isotope hydrology TC project in Eritrea, and 'Applying Nuclear Techniques for the Monitoring and Protection of Surface and Groundwater Resources' (ERI8003), is the continuation of the first project. In southeast Eritrea, available water has been highly scarce (facing page, bottom). Total surface water and groundwater (excluding overlap), for example, only amounted to 701 m<sup>3</sup> per capita in 2001 (compared to 5705 m<sup>3</sup> per capita in sub-Saharan Africa), and irregular and



Groundwater samples reveal a stable water isotope slope below the global meteoric water line (top figure). The Br/Cl of groundwater suggests an evaporation effect (bottom figure).

unreliable rainfall in recent years has been exacerbating water resources scarcity.

Under project ERI8002, water samples were collected from 12 wells in the Assab well field for isotope and hydrochemistry analyses (below right). In groundwater



Drilling for water in Eritrea (left). Available water has been highly scarce. The figure on the right displays wells in the Assab region where water samples were collected for isotope and hydrochemistry analysis (Photo credit: Ministry of Land, Water and Environment, Department of Water Resources).

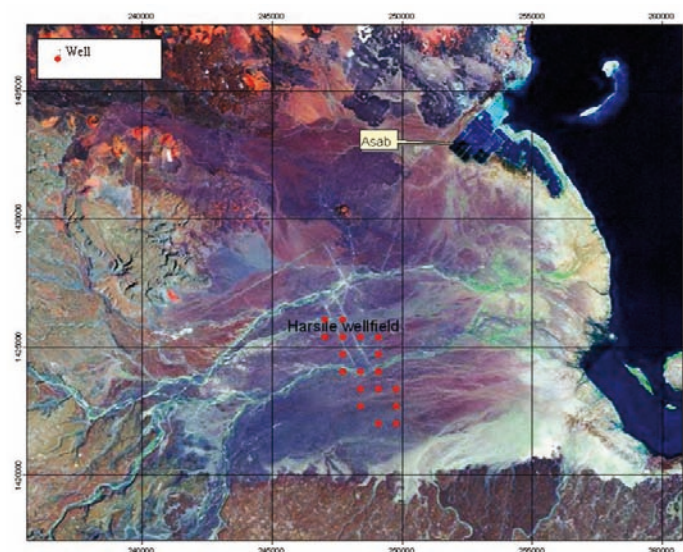
samples, temperatures were relatively high (33–35°C), chloride concentrations (28–250 mg/L) were high in some samples. Groundwater samples revealed a stable water isotope ( $\delta^2\text{H}/\delta^{18}\text{O}$ ) slope of 6.8, below the Global Meteoric Water Line (figure left, top:  $\delta^2\text{H}$  vs.  $\delta^{18}\text{O}$ ). The Br/Cl ratio against the Cl concentration of groundwater was greater than the ratio of seawater origin (figure left, middle), while the  $\delta^{18}\text{O}$  vs. Cl of groundwater suggests an evaporation effect. Tritium concentrations in most wells were between 1 to 2 TU,  $^{13}\text{C}$  values (–13.3 to –9.7‰) and magnesium concentrations (20–60 mg/L) were much lower than those of seawater origin, while  $^{14}\text{C}$  values were between 34–76 pMC; electrical conductivity decreased with increasing deuterium excess (d-excess). Together, these results suggest that elevated salinity in groundwater is not likely due to the intrusion of seawater, but is probably resulting from evaporation together with mixing with brackish water from deep aquifers. Further studies are expected to confirm these preliminary findings. Despite some difficulties, such as restricted access to the field site in Assab, a new sampling campaign was undertaken in 2009 and these water samples are expected to soon be analyzed for isotopes and hydrochemistry. The goal of these isotope hydrology projects in Eritrea is to characterize the country's aquifers and through this information secure a safe drinking water supply.

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# Protecting Drinking Water in Central Georgia

By G. Melikadze, T. Chelidze, M. Nodia Institute of Geophysics of Ministry of Education and Science of Georgia, Tbilisi

*The opening of the Baku-Tbilisi-Ceyhan oil pipeline in 2005 raised questions about whether potential pipeline leakages could influence the water supply of nearby springs. A Technical Cooperation project was launched to evaluate the vulnerability of the area.*

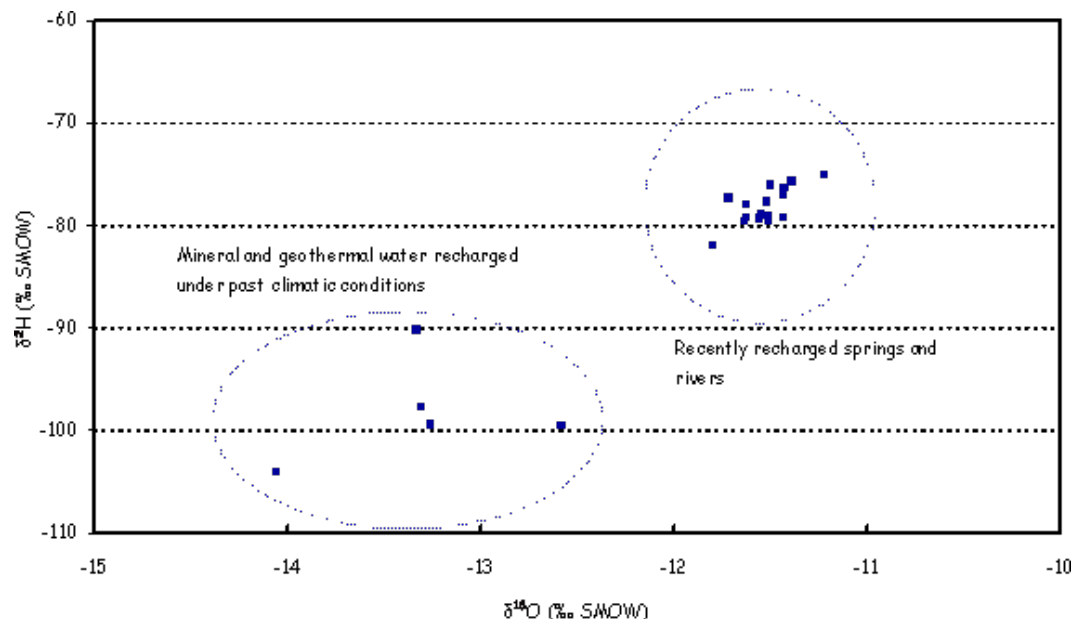


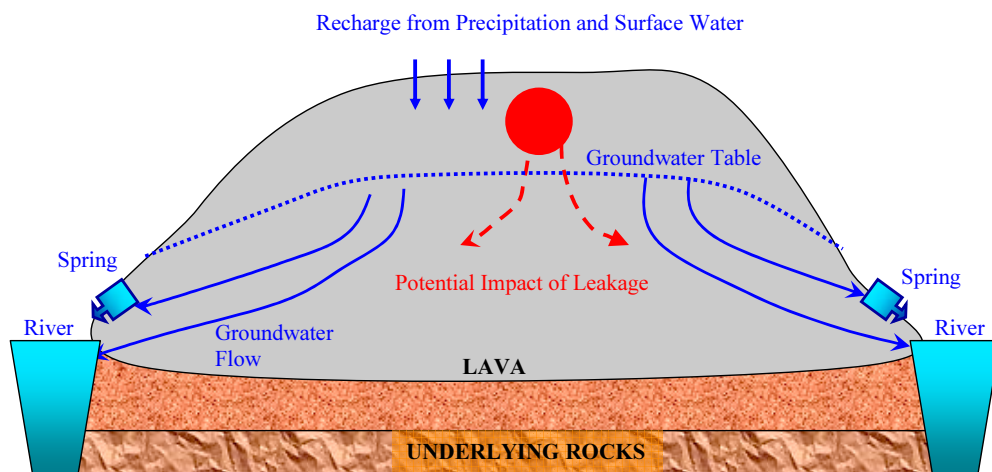
Map of Georgia, with the location of the study area marked in red.

The Borjomi area in Central Georgia is known for its good drinking water, including the famous Borjomi mineral water springs and several captured springs in the nearby volcanic formations of the Little Caucasus Mountains. The opening of the Baku-Tbilisi-Ceyhan oil pipeline in 2005, however, raised the question whether a potential leakage of the pipeline crossing the recharge area near Borjomi might impact the springs' water supply.

The Georgian government and the M. Nodia Institute of Geophysics of the Georgian Ministry of Science and Education have thus launched a Technical Cooperation (TC) project with IAEA's assistance to assess the origin and subsurface pathways of groundwater captured in the springs, and on evaluation of their vulnerability in case of potential leakage of the pipeline.

*This graph shows that two principal groundwater types exist; mineral and geothermal groundwater recharged under past (colder) climatic conditions, and a recently recharged groundwater source supplying the region's drinking water system.*





*Profile of the volcanic formation in the Borjomi–Bakuriani area, showing groundwater flow (blue) to rivers and drinking water springs as well as the potential impact (red) of an oil pipeline leak.*

## The Project

Project GEO/8/003, ‘Using Isotope Techniques to Assess Water Resources in Georgia’ was the first IAEA–TC project in water resources undertaken in the Borjomi area. Its purpose was to evaluate the origin and subsurface pathways of groundwater captured for the drinking water supply of Borjomi City in Central Georgia. Water monitoring and sampling campaigns provided information on the isotopic and chemical composition of groundwater in springs and nearby rivers.

Two principal groundwater types can be distinguished through stable water isotopes (previous page, bottom figure) — mineral and geothermal groundwater recharged under past (colder) climatic conditions, and a recently recharged groundwater source supplying the region’s drinking water system. The resulting conceptual model (above) shows that the drinking water springs are largely supplied by fresh groundwater which can be rapidly affected by potential

contamination in the infiltration zone. However, the Borjomi mineral waters, captured from deeper boreholes, were recharged during a much earlier period than in other areas. It is unlikely that these deep waters can be affected by pollution from the pipeline.

The recharge area of the Borjomi drinking water has been found to be vulnerable, thus recommendations have been made to improve protection of the oil pipeline in the critical sectors of the infiltration zone, and there is also a proposal for a contamination alarm system. The project demonstrated the usefulness of isotope techniques, complemented by other methods and applied with a thorough understanding of the principal geological features of the area. It has been implemented through good collaboration between the principal Georgian counterparts as well as local water managers.

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*Oil pipeline sector in the recharge area of the Borjomi mineral and drinking water springs (left). Drinking water tanks near the city of Borjomi (right).*



# Training Workshop Undertaken in Ethiopia

*Students at a training session in Ethiopia (Photo credit: IAEA).*



The IAEA has been working with the Ethiopian government through Technical Cooperation (TC) and African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) programmes since 1992. To date, seven TC and three Regional Africa (RAF) projects have been conducted in Ethiopia. The prime objective of these projects has been to build capacity, enabling Ethiopia to develop and manage its water resources wisely.

The IAEA's support to Ethiopia covers the following five major areas:

- Supply of scientific equipment;
- Isotope analysis;
- Provision of expert services;
- Training and scientific visits;
- Establishment of a National Isotope Hydrology Laboratory (NIHL) at Addis Ababa University.

Environmental isotopes have been used to define recharge rates and provenance, surface water–groundwater interaction and geothermal resource assessment in the Ethiopian Rift valley and adjacent upland areas. Under TC and RAF projects, a large number of water samples have been analyzed for isotopes ( $^2\text{H}$ ,  $^3\text{H}$ ,  $^{18}\text{O}$ ,  $^{13}\text{C}$  and  $^{14}\text{C}$ ) at the IAEA's Isotope Hydrology Laboratory in Vienna.

A national laboratory for isotope hydrology — equipped with a tritium counter, AAS, IC and Laser Isotope Spectroscopy — has been set up at Addis Ababa University with financial support from the Agency. Since the establishment of the new lab in 2007, stable isotopes ( $^2\text{H}$  and  $^{18}\text{O}$ ) and tritium have been locally analyzed.

Since 1992, five national training workshops have been conducted in Ethiopia. The themes were basic isotope hydrology, isotope and chemical data interpretation, isotope

and chemical modelling and field sampling techniques.

## Training

An isotope and chemical modelling workshop was conducted at Addis Ababa University as part of ongoing TC project ETH8010 (Assessment of Groundwater Resources in Selected River Basins) at the beginning of this year (4–15 January 2010). The workshop was attended by 20 participants from several Ethiopian organizations; the majority were postgraduate students and staff from Addis Ababa University. Others attended from the Geological Survey of Ethiopia, Regional Water Resources Bureaus, the Ministry of Water Resources and the Ethiopian Groundwater Resources Assessment Program (EGRAP).

The class was exposed to intensive theoretical lectures and practical exercises. Concepts and methodologies of isotope and chemical modelling were addressed in depth. State of the art isotope and hydrogeochemical modeling using computer codes PREEQC, NETPATH and FlowPC were also covered. Most participants were young postgraduate students, whom it is anticipated will enhance the knowledge attained from this workshop through postgraduate learning and research. Most of them were inspired by isotope and geochemical modelling techniques.

Brent Newman from the IAEA, Karsten Osenbrueck from UFZ-Germany and Paula Carreira from Portugal taught the two week class, while Zenaw Tessema from the Geological Survey of Ethiopia coordinated the course. During the workshop, CDs containing lectures, exercise datasets, software and pertinent publications were distributed to all participants of the workshop, as well as isotope hydrology CDs. At the end of the workshop, all participants received a certificate of attendance from Addis Ababa University.

# Danube Basin Meeting Focuses on Specifics



*The Danube River at the Iron Gate Gorge in Serbia.*

A two day workshop held at the Vienna International Centre from 11–12 May focused on the causes of nitrogen issues in the Danube Basin and what actions are needed to reduce nitrogen input.

Twenty-five participants attended the workshop, which was coordinated by the Water Resources Programme and the International Commission for the Protection of the Danube River (ICPDR). Many of the participants are involved with ICPDR expert groups. The goal of the meeting was to bring together people working on nitrogen problems in the Danube basin, to discuss the current status of nitrogen issues in the basin, to collate relevant data sources and references, to identify key knowledge gaps in relation to basin nitrogen, especially in the context of the EU Water Framework Directive, and to identify which knowledge gaps can be reduced or eliminated through additional studies or activities.

Workshop outcomes focused on three main areas:

1) What data/information on nitrogen in the Danube is available?

It was found that information can be gathered from many sources, including initiatives under the ICPDR/EU and the national levels, MONERIS (Modelling Nutrient Emissions in River Systems) results/inputs, isotope data, and flow rate and discharge data as well as precipitation/meteorological data.

2) What are the key needs/issues/data gaps?

At the basin or transboundary scale, maps on groundwater residence time can forecast changes in the basin, mark

out groundwater discharge areas, and determine the age of groundwater entering the river. It was determined that the overall information and data availability on basin nitrogen balance needs to be improved, and many questions need to be answered, such as why there are deviations of MONERIS with altitude, and how the effect of settlements can be accounted for. As well, more emphasis could be placed on tributaries in terms of groundwater connection, which implies understanding the flow between different water systems. Large uncertainties remain regarding nitrogen sources in the basin, and additional information is required to understand floodplain restoration and its long term effects, as well as adequately understanding the flow regime. Research also is needed to understand the old nitrogen composition of the Danube and whether it has changed over time, and what effects reservoirs have on nitrogen cycling. Understanding old groundwaters with high ammonia rates would also be desirable.

At local or national scales, understanding soil/unsaturated zone transformations is an issue, as well as the distributions of nitrate in deep groundwater. Some specific countries have particular areas of concern that should be addressed.

3) What support is required/available (technical/funding)?

It is suggested that a consortium be developed to propose work on nitrogen in the basin. The IAEA can provide technical expertise and some isotope analyses, while the European Science Foundation can aid in training and technical exchange. JDS-3 is planned for 2013, and the ICPDR Expert Group meetings can be used to help facilitate and coordinate projects. Labs for nitrogen and cesium isotope analysis can be made available.



# Early Vignettes from Isotope Hydrology

*Some early scientists working in the young field of isotope hydrology tell stories about amazing and funny incidents which took place during the developmental years of the science.*

## GNIP 'Childhood Diseases' in the Mediterranean Region

**By Joel Gat** (long-time isotope hydrologist from Israel and supporter of IAEA programmes)

The first collection of cumulative monthly precipitation samples for isotope analysis was organized during the early 1960s, mostly in cooperation with local meteorological services. The procedure involved gathering water from standard meteorological rain collectors after each precipitation event and transferring it into a sealable storage bottle, in which the total monthly sample was then accumulated. In order to be sure that a reliable and representative sample was obtained, collection sites were selected where a learned and trustworthy person was in charge. How this strategy backfired at times is illustrated in the following examples from the eastern Mediterranean network in the infancy of GNIP.

### Turkey

A station in the Taurus mountains was established to characterize the precipitation in Turkey originating from Mediterranean moisture. Being a mountain station, precipitation consisted of both rain and snowfall. After the Turkish network had been operating for about a year, we visited all sampling sites together with representatives of the Turkish Meteorological Service. During the inspection tour of that station, a young operative approached me, asking quietly if the samples were destined for my use, adding: "I am not sure you are getting what you need for your purpose". He went on to explain that in the case of snowfall, when the snow accumulates on top of the collector it is melted with the aid of a known volume of hot water, the volume of which is then subtracted from the total volume to get the corrected amount of precipitation; ouch!

### Cyprus

A preliminary network was established at sites recommended by the British Meteorological Supervisor (Cyprus was at that time still under British supervision and — typical for all former British colonies — abundant in red telephone booths and lots of precipitation samplers). One station recommended by the supervisor was in a small township situated on top of a mountain, where the rain



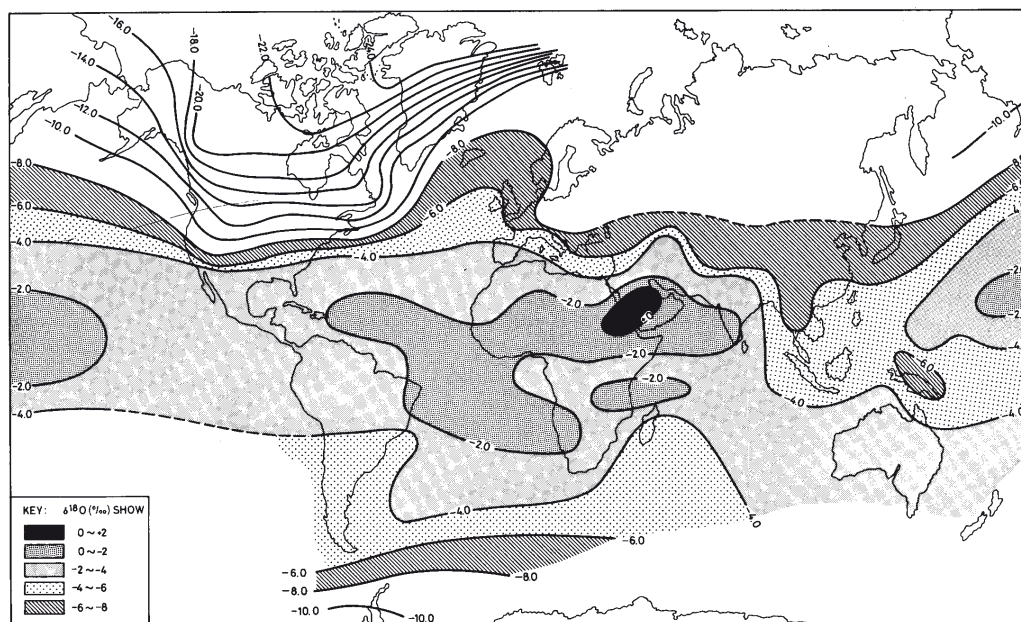
*A modern GNIP station.*

sampler was stationed in the local schoolyard under the care of the teacher, a learned and reliable man.

After some months of operation I was, however, informed by the supervisor to discard the results from that station. It transpired that the rain amounts recorded at that station were consistently in excess of all surrounding ones. Upon investigating, he found that the rain collector was stationed in a corner of the schoolyard, surrounded by a low fence in order to prevent unauthorized access to it. However, this apparently soon became the object of a competition by the macho students, to see who could reach the collector by peeing (and some apparently succeeded).

Postscript: Surprisingly the isotopic values were not noticeably aberrant, which could be explained by the similarity of the isotopic composition of the boys' body fluids with the local drinking water, a feature later to be exploited for the forensic application of the isotopic composition of water.

A classical historical map from the late 1970s; one of the first maps showing distribution of oxygen-18 in precipitation (taken from the monograph *Stable Isotope Hydrology, Deuterium and Oxygen-18 in the Water Cycle*, 1981).



## Israel

The mountain station at Tirat-Yael in the Gallilean Mountains was operated by a retired agricultural engineer who had settled there and conducted occasional tests for the agricultural research station. He expressed great intellectual curiosity regarding the programme and its use. On one occasion when we collected the accumulated samples at the end of the rainy season, he told us about one of the storms which — according to his experience — was very unusual and of great meteorological interest. To do justice to this situation, he told us proudly, he had put double the amount of this precipitation event into the monthly sample: ouch!

As results from the Mediterranean region became available, it transpired that meteoric waters in the eastern Mediterranean region showed a higher d-excess value than those of the worldwide Global Meteoric Water Line (GMWL), defined by Harmon Craig. When this was discussed with Harmon, he expressed astonishment (and doubt concerning the veracity of the isotopic analysis), since among the samples on which he based his conclusion were three from that region which appeared not to be aberrant in any way.

These three samples were provided to him by a tourist to the region and consisted of one water sample collected from the faucet of a seaside hotel near Tel-Aviv (Israel), one from a deep well water sample from the Arava Valley in the Negev Desert area, and one from a geothermal spring from the Jordan Rift Valley. These were indeed interesting, though atypical, samples consisting of a sample from the coastal aquifer which represents partially re-evaporated residue of the local precipitation, a paleo-water sample and one which evidently was modified by high temperature interaction between meteoric water and rock formations.

**By Roberto Gonfiantini** (former Isotope Hydrology Section Head)

## New Zealand

After some years of rain collection, a IAEA Hydrology Section member (Claude Taylor), who was from New Zealand, noticed that the stable isotope values of precipitation at a local station located in his country were generally less negative than what he had expected on the basis of his knowledge of the region and his isotopic data on groundwater. Thus, he took the opportunity to inspect the station during a trip to the area for personal reasons. It appeared that the monthly 'precipitation' samples were collected, at the end of each month, from an evaporation pan class A, which was mostly fed by rain. As a consequence, all the results previously accumulated had to be discarded.

The problem of correct precipitation sampling has always been a serious one, in spite of detailed instructions provided by the IAEA. The main reason is that the station operators often have no idea of isotope behaviour when samples are left exposed to the atmosphere. Samples are meant to be gathered in collectors which are then isolated from the atmosphere so they cannot be affected by evaporation or other outside contamination. Regular control of all operating stations would be too expensive and time consuming and is simply not possible. However, nowadays the situation is much better; national meteorological services have become more and more aware of the problems associated with precipitation sampling for isotope analyses and exercise some control over station operations. In addition, the isotopic data are carefully controlled at the IAEA and those suspected of being affected by errors in sampling and/or isotope measurement are discarded.



## Dead Sea Anecdote

By Joel Gat

During the 1940s, towards the end of the war years, while Palestine was still a British mandate, L. Farkas, Professor of Physical Chemistry at the Hebrew University in Jerusalem and world renowned scientist, was among the first to utilize tracer methodology in the study of chemical reactions and in particular ortho- and para-hydrogen and heavy hydrogen, in continuation of studies performed by him in Cambridge (UK) in the 1930s.

At that time, deuterium was painfully enriched through electrolytic decomposition of ordinary water; the Germans had an advantage because they could utilize cheap Norwegian electricity. It was, however, already known that a similar result could be achieved by means of the fractional evaporation of water.

Thus, it occurred to Prof. Farkas that since Dead Sea waters are expected to be enriched in heavy isotopes relative to seawater due to their terminal situation — which also led to the sea's high salinity — it would be a preferred starting point for the further enrichment of deuterium. Since at that time the determination of the heavy isotopic component in water relied on density measurement, Prof. Farkas asked a doctoral student to build a thermostat which would be accurate to  $\pm$  one thousands of a degree, and then compare the densities of water distilled from seawater and Dead Sea water respectively. It took the student about a year to finish his task satisfactorily.

Prof. Farkas was generally a very amiable person, so it surprised us graduate students to hear him one day shout angrily: “This cannot be true, what have you done wrong?”

It had transpired that the student reported to him that there was no measurable difference between the densities of the two water samples. Whether this was an experimental error or indeed a fact remained a mystery for many years. It was only following the introduction of mass-spectrometric analysis that a reliable determination of the deuterium abundance in Dead Sea water became available. This was documented by J. Gat in 1984, H. Craig in 1954 and 1956 and later W. Dansgaard, A. Nissenbaum, then the Weizmann Institute Dead Sea Expedition team: Each confirmed the value of  $2\delta$  in Dead Sea waters to be indeed close to that of seawater.

It had of course not yet been realized by early researchers that Dead Sea water was not a product of seawater evaporation but that it originated from inland waters, namely the Jordan river system, with very depleted isotopic values and that further salinity effects on isotope fractionation during evaporation were at play.

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## New ‘Tips and Tricks’ factsheet to be posted on the Isotope Hydrology web site

The Isotope Hydrology Section will be posting its updated laser analyzer troubleshooting tips fact sheet on the Section's webpage, at <http://www.iaea.org/water>.

The ‘Tips and Tricks’ factsheet includes various, typically undocumented, approaches and lessons learned that users of the LGR DT-100 have found useful in operating, maintaining and troubleshooting their instruments. The factsheet — initially produced as an outcome of a users' meeting held at the IAEA in December 2009 — contains assorted information that can help users keep their instruments running and produce better analyses. A word of caution: the IAEA has not tested all of these tips and tricks, so use them with caution and at your own discretion.



*A laser analyser training session at the IAEA laboratory. The Section has produced a ‘Tips and Tricks’ factsheet based on the experience of users.*

## The beginning of a long cooperation

By Joel Gat

1962: I travelled to Vienna on the occasion of the 1st Symposium on the use of Tritium in the Physical and Biological Sciences to present our findings on tritium in precipitation in the Mediterranean region (Gat, Karfunkel and Nir). I did this with some apprehension, as our measurements of the tritium content of the Mediterranean surface waters did not quite match data reported by W. Libby, the Godfather of tritium measurements, who was also expected to be present. [see below the relevant discussion as given in the proceedings].

During one intermission, a young colleague approached me, introduced himself as Willie Dansgaard from Denmark and said as follows: "I understand you are from Israel, may I ask you for a favour?" and he went on to explain that he was investigating the enrichment of the heavy water

isotopes as a result of evaporation in the open and for that purpose he had put an evaporation pan on the roof of the laboratory in Copenhagen, which he sampled every day as the water evaporated from the pan. His problem was that before he could get a meaningful result, rain occurred and perturbed the system. "I understand you have a long dry period; so my request is for you to conduct this experiment there and then send me the samples for analysis." He also offered to analyze any additional water samples of interest from our hydrological system. Why bother with tritium measurements after this?

A long cooperation developed, with many visits, training of our technician in his laboratory and the first comprehensive stable isotope survey of the Eastern Mediterranean hydrological cycle, summarized in 'Stable isotope survey of the freshwater occurrences in Israel and the Jordan Rift Valley' [Gat, Dansgaard, J. Hydrology vol.16, pp.177–211, 1972].

### DISCUSSION III (Proceedings of the 1962 IAEA Symposium)

F. Begemann (Federal Republic of Germany): Dr. Gat cited a figure of 10 T.U. for the surface water of the Mediterranean in 1960. Has this value been measured or was it calculated from the average depth of the sea, on the assumption that there is complete mixing?

J.R. Gat (Israel): The value is a measured one, based on three water samples from the eastern Mediterranean basin. It is somewhat higher than the figures of 2.5 and 5.5 reported by Prof. Libby in his paper on the central Mediterranean basin. We do not know the reason for the discrepancy between the two results. It may be due to some local circulation pattern. Obviously, many more measurements will have to be taken. However, the absolute values do not greatly affect the picture we have drawn on the basis of rain levels, which are much higher anyway.

W.F. Libby (United States of America): I am pleased to report that we are re-measuring these surface values for the Mediterranean and that our newer values are higher. Instead of 5.5 T.U., the new figure is about 7-8, which is more in line with that reported by Dr. Gat.

## News in Brief

### New Staff Members

- Mr. Manzoor Ahmad Choudhry joined the Isotope Hydrology Section as an isotope hydrologist in April 2010. Mr. Choudhry was formerly Head of the Isotope Application Division at the Pakistan Institute of Nuclear Science and Technology (PINSTECH), Islamabad, Pakistan. He worked on the application of isotope techniques in groundwater–surface water interaction, groundwater pollution, geothermal investigations, soil erosion and sedimentation. At the Section, he will be mainly involved in the application of environmental isotopes in groundwater investigations and interactions between water in snowpack, glaciers and permafrost, groundwater and surface water.

- Mr. Zenaw Tessema Kassa joined the Isotope Hydrology Section as a consultant in April 2010. Mr. Kassa has been working for Geological Survey of Ethiopia as head of the groundwater division and programme manager of the Ethiopian Groundwater Resources Assessment Program (EGRAP). Since 1995, he has been working as a hydrogeologist and the main counterpart in IAEA financed isotope hydrology projects. His academic training is in geology and hydrogeology. Mr. Kassa will be assisting in the implementation of technical cooperation projects with emphasis on implementation of a project entitled Mainstreaming Groundwater Consideration into the Integrated Management of the Nile River Basin (RAF/8/042).



- Ms. Kyoko Viitaniemi joined the Isotope Hydrology Section as a clerk in February 2010. Previously she worked as an assistant to the Ambassadors in the Permanent Mission of Japan to the International Organizations in Vienna.

## Meetings

- The Water Resources Programme sent a representative to the UN-Water Task Force on Water and Climate Change Workshop on 'Key Challenges to Adaptations in the Water Sector'. A mapping exercise was conducted to identify and analyse main strengths and gaps in activities carried out by members and partners of UN-Water. The final aim of the exercise is to promote closer collaboration and coherence in work carried out by UN-Water organizations in line with activities on climate change adaptation and mitigation.

The IAEA contributed to the mapping exercise by providing information on activities and projects related to water and climate change involving both the Water Resources Programme and the Soil and Water Management and Crop Nutrition Section of the Joint FAO/IAEA Programme. These activities, including Technical Cooperation projects, were grouped into three main categories: Isotope methods for improved understanding of the water cycle; sustainable use and management of water and agriculture, and; a new project being undertaken by the IAEA on Water Availability Enhancement.

The participation of the IAEA through the Water Resources Programme in the coordination of UN-Water task forces is helping to promote and provide more visibility to the role that isotope hydrology and related disciplines play in the assessment and management of water resources in Member States.

## Training

- The Water Resources Programme held a training course on the installation and use of the LGR laser stable isotope analyser from 1–5 February 2010. The training included lectures on theory and basic operation of the machine, viewing of the installation video, practical training on installation and running of the machine, including test samples, a demonstration on post-processing using spreadsheets, a troubleshooting demonstration, preparation of standards and proper storage of the machine. This is one of a series of training courses conducted by the IAEA to teach representatives from Member States how to analyse their own stable isotope samples.

## Note

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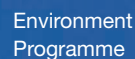
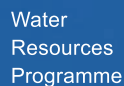
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Contributions to the newsletter are welcome.

# Meetings in 2010

- Training for National Consultants and SAP Workshop, Nubian Sandstone Aquifer Project, Vienna, Austria, 19–20 July.
- First Research Coordination Meeting on Isotope Methods for Assessing the Impact of Climate Change on Water Resources in Snow, Glacier and Permafrost Dominated Areas, Vienna, Austria, 30 August–3 September.
- Final Research Coordination Meeting of the Coordinated Research Project Isotope Techniques for the Evaluation of Hydrological Processes in Wetlands, Vienna, Austria, 6–9 September.
- Technical Meeting on Integration of Isotope Data in Rainfall-Runoff Models for Characterizing Watershed Hydrology, Vienna, Austria, 18–22 October.
- Research Coordination Meeting on Tritium-<sup>3</sup>He Dating and Noble Gas Techniques in Water Resources Management: Recharge, Infiltration Conditions and Groundwater Balance, Vienna, Austria, 8–12 November.



International Symposium on  
**Isotopes in Hydrology,  
Marine Ecosystems,  
and Climate Change Studies**  
Organized by the  
International Atomic Energy Agency  
Hosted by the

Organized by the  
International Atomic Energy Agency  
Hosted by  
Principality of Monaco

**Oceanographic Museum of  
Monaco  
27 March – 1 April 2011**

*The Isotopes in Hydrology, Marine Ecosystems and Climate Change Studies* symposium will analyse and review the current status of the application of a spectrum of isotope techniques in hydrology, marine ecosystems and climate change. It is hoped that this joint symposium will stimulate the international exchange of information and ideas that will contribute to greater accessibility and enhanced use of isotope techniques at local, regional and global scales in these areas. For more information on deadlines and the programme, please visit [www.iaea.org/meetings](http://www.iaea.org/meetings).

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