WATER & ENVIRONMENT NEWS

A Newsletter of the Isotope Hydrology Section

Photo credit: PANG Zhonghe/IAEA

A new vacuum distillation system for tritium sample preparation, see inside for story

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FROM THE SECTION HEAD...

I am happy to report that the new year begins with our programme having made strides in strengthening its core activities. Several new initiatives were taken to increase the use and application of isotopes in hydrologic practices. New research projects were planned and will soon be initiated for isotope monitoring of submarine groundwater discharge and of global rivers. These projects are aimed at a better assessment of freshwater resources, improved coastal zone management, and understanding hydroclimatological processes. An important aspect of these new projects is the increased inter-agency collaboration with UNESCO's IHP and IOC, and potentially WMO's global runoff data center. This is intended to bring project results into focus as soon as they are available and to increase the recognition for the role of isotope applications. Another new area of application to be taken up is artificial recharge where established isotope techniques have a direct application and potential benefits.

Four coordinated research projects were completed last year related to (1) radionuclide transport in surface and groundwater systems in areas affected by the Chernobyl fallout, (2) water quality assessment of surface water bodies impacted by sewage discharges, (3) the management and protection of aquifer systems in major urban areas, and (4) geothermal exploitation.

There was a substantial increase in technical cooperation activities. Funding for isotope hydrology projects has nearly tripled in the last five years to about US$ 8.9 million for the 2001-2002 cycle. More than 52 TC projects in isotope hydrology were operational during the 1999-2000 cycle. Some of the highlights of the TC projects are included in this issue. As in the research activities, we are trying to integrate isotope hydrology into water resources management practices as much as possible. In Ethiopia, a national plan for groundwater resources assessment was formulated in cooperation with the US Geological Survey and a variety of governmental and non-governmental entities of Ethiopia. It is anticipated that this plan, upon implementation, will guide the national and international efforts for groundwater resources assessment and management over 10-15 years and ensure ready integration of isotope techniques into hydrologic practices.

We recognize that one of the impediments in wider use of isotope hydrology is the lack of trained manpower and access to analytical facilities. To overcome this constraint, a new IAEA/UNESCO programme initiative, Joint International Isotopes in Hydrology Programme (JIIHP), was launched. JIIHP will allow participation of and information dissemination to a wider group of practicing and research hydrologists in Member States through UNESCO's International Hydrological Programme (IHP) network. A laboratory network is being established to increase the participation of analytical facilities available or anticipated to be available in national and regional laboratories. The objective is to reduce the level of routine analytical service provided by the Agency's laboratory while strengthening Member State laboratories through increased support for quality assurance and quality control procedures. In addition, a feasibility study for using an optical technique to measure stable isotope ratios in water was initiated in collaboration with Rutgers University, USA. Isotope measurement machines using the optical technique can be deployed with minimal infrastructure support and would have several advantages over the mass spectrometer techniques that are used today, including lower acquisition and maintenance costs, relatively low levels of operational skills and consumable items, and minimum infrastructure requirements.

The coming year promises to be as exciting as the last one and will have a good beginning with a conference on isotopes in climate change studies. About 100 papers were received and a fairly busy programme with about 50 oral presentations has been planned. We are also planning to constitute IAEA working groups with three year terms, somewhat along the lines of other agencies, to guide the Agency's programme on major issues of hydrology and climate studies through advice and collaboration over an extended period of time, as opposed to contributions through single and unrelated meetings.

While we list the successes and achievements of the Section, it is implicit in our statements that this is not just the effort of the staff here at the IAEA, but the collective effort of the whole isotope hydrology community. Without active participation of so many of you in the research and TC projects, we will have no hope for success. A big Thank You to all those who contributed in one form or the other.

Pradeep Aggarwal

ISOTOPES IN GROUNDWATER SALINITY STUDIES

A CRP on "Origins of salinity and impacts on fresh groundwater resources: Optimization of isotope techniques" with the participation of 12 Member States was recently initiated.

The 1st coordination meeting of the CRP was held in Vienna from 18 to 22 December 2000. The participants gave information on their study sites in the respective countries and the specific salinity related issues to be investigated.

Following an agreement on one of the sites as a focus, the debate centered on how the other areas would best fit the goals of the CRP programme. Each of the country proposals was evaluated in terms of how they meet several pre-defined criteria which were found to be the most important for site selection.

The Souss-Massa coastal plain in southwestern Morocco was proposed as the main site and it was generally accepted that this offered scope for studying both coastal (saline intrusion) and inland basin problems. The plain is formed by a basin located between the High-Atlas mountains in the north, the Anti-Atlas in the south, and the Siroua massif in the east, and is open on the Atlantic ocean in the west. Temporary water courses are collected by Oued Souss which crosses the plain from east to west. The plain is covered by thick detrital Plio-Quaternary deposits (conglomerates, clay, sandstone and marly-calcarous) underlining a Cretaceous-Eocene east-west syncline (clay and marls and marly calcareous). The Triassic, Liassic and cretaceous formations in the High Atlas contain evaporites. The general flow in the aquifer is east to west. In the North and in the South, the piezometric contour map demonstrates a recharge flow from the High-Atlas and Anti-Atlas. Some depressions also exist in the central part of the basin related to the over-exploitation.

Taking into account the geological, hydrogeological and limatic context of the region, several sources could be the reason for the groundwater salinity:

(1) present-day marine intrusion,
(2) old marine intrusion,
(3) water rock interaction and dissolution of evaporites,
(4) concentration by evaporation,
(5) anthropogenic pollution.

Interpretation of the first chemical and isotopic results gives indications on the sources of salinity. In particular, the Br^-/Cl^- and Sr^{2+}/Ca^{2+} ratios were used to distinguish (1) marine influenced areas (present day or paleo seawater intrusion?), (2) evaporites influenced areas; (3) in a few localized wells near the downstream part of the Oued Souss, waste water. Nitratessouth of the basin show the influence of agricultural practices.

The study has the following objectives: It will provide the opportunity to apply a multi-isotope approach of the salinity problem using on the same site several isotope tracers in combination. These will include $^{11}B/^{10}B$, $^{87}Sr/^{86}Sr$, ^{129}I, ^{36}Cl, ^{37}Cl, ^{81}Br, together with the more classical isotopes such ^{18}O, ^{2}H, ^{13}C, ^{14}C, ^{34}S, $^{18}O_{SO4}$. (see table). It will be also important to determine, if it occurs, the intrusion of old sea water, which is a fundamental problem related to the climatic changes and to the variations of the sea level during the Quaternary.

Although the flagship site is the main target of the CRP, it was agreed that opportunities for collaboration between all participants are required and a networking approach would be adopted to achieve these goals. The scientific approach, emphasizing isotope techniques to be used in the CRP, was discussed and the programme of work for the global CRP as well as for the participants was adopted.

MONITORING ISOTOPES IN RIVER WATER

For about four decades, the IAEA, jointly with WMO, has been monitoring isotopes in precipitation worldwide. This programme is known as GNIP-Global Network for Isotopes in Precipitation. With the increased demand from the scientific community and the hydrological practices for the basic isotopic data in the water cycle, initiatives are being considered to include river water in the network. To this end, an Advisory Group Meeting was held at the IAEA Headquarters in Vienna, Austria, 4-6 December 2000 to discuss this issue.

The GNIP programme was launched with the primary objective of collecting systematic data on isotope content of precipitation on a global scale, characterising their spatial and temporal variability and, consequently, providing basic isotope data for the use of environmental isotopes in hydrological investigations. It was realized soon that the collected data are also useful in other water-related fields such as oceanography, hydrometeorology and climatology.

Precipitation stations only represent small areas, and the location of the station is crucial to the results. Minor local changes may affect isotopic values at a precipitation sampling station. Therefore, isotopic shifts may not represent changes in the whole area. One way to overcome this problem is to increase the sampling density for precipitation, which would result in increased time and cost. Analysis of river and stream water offers a second option. River water integrates precipitation, both in time and space. A river water sample represents integrated precipitation from the entire basin, although the influence of the various parts of the basin can vary in time.

Several issues that can be investigated by using isotopic data of river water have been identified. They are climate change, time scales of processes in the basin, land use changes, establishing isotopic source functions for other studies, pollution tracing, flux estimates, and biological changes with time.

A protocol is needed for determining the best sampling strategy in terms of choice of rivers, locations, and timing of sample collection. For example, there are several time scales available to study isotopic distributions in river systems. There is the short-term, or synoptic time scale in which one collects data on a daily or weekly basis, an annual cycle in which one collects samples to observe a yearly trend, and long-term collections which are multi-year or decadal time scales.

A Co-ordinated Research Project (CRP) will be initiated to develop the protocol. The approach would entail both the analysis of existing data sets and implementing a new sampling programme.

A FIELD MANUAL ON ISOTOPES FOR GEOTHERMAL INVESTIGATIONS

ISOTOPIC AND CHEMICAL TECHNIQUES IN GEOTHERMAL EXPLORATION, DEVELOPMENT AND USE: SAMPLING METHODS, DATA HANDLING, INTERPRETATION

This publication, edited by Stéfan Arnórsson, is designed as an instruction manual of essential nuclear and complementary methodologies for a multidisciplinary approach to geothermal exploration development and monitoring. It provides comprehensive procedures for carrying out isotope and geochemical investigations of geothermal systems, i.e. sampling, analysis and data interpretation. It will be a valuable source of information for geoscientists working in geothermics, but also for those working in cold water projects, due to the similarity of methods and principles of investigations applied.

Contents: 1. Introduction; 2. Strategy in geothermal exploration, development and production; 3. Chemical reactions and chemical equilibria; 4. Reactive and conservative components; 5. Isotopes for geothermal investigations; 6. The source of chemical and isotopic components in geothermal fluids; 7. Geothermal manifestations and hydrothermal alteration; 8. Sampling of geothermal fluids: On-site measurements and sample treatment; 9. Presentation of analytical results, analytical precision and accuracy; 10. Geothermometry; 11. Mixing processes in upflow zones and mixing models; 12. Assessment of reservoir fluid composition from wet steam well data; 13. Hydrogen and oxygen isotopic fractionation during. 14. Mineral saturation; 15. Estimation of aquifer steam fraction; 16. Monitoring of reservoir response to production.

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STUDY OF PRESPA LAKE USING NUCLEAR TECHNIQUES

Prespa Lake is situated on the borders of Albania, TFYR of Macedonia, and Greece. The water level in the lake normally follows an annual cycle, with highs in May/June and lows in Autumn.

Since 1986, a continued fast decrease of the water level has been observed. A drop of 7.4 meters has taken place if the level of 845,5 m.a.s.l. at the end of 1995 is compared with the peak of 852,9 meters observed in 1952.

This significant decrease of the water level disturbed the ecological balance of the lake, affecting to a large extent the fishing and tourist industries. In addition, the industrial activities as well as the overuse of the herbicides in agriculture raised the problem of contamination of the lake water.

A regional project sponsored by the IAEA (RER/8/008) is aimed at providing a scientific basis for sustainable environmental management of the lake. Based on the characteristics of the observed Prespa/Ohrid regional hydrosystem, the existing problems require international co-operation and the application of nuclear and related modern techniques.

The hydrological relation between Prespa and Ohrid and modelling of the Prespa lake water level fluctuation were the main issues discussed.

According to the existing hypothesis, water from the Prespa Lake flows through the karstic mountains and appears at the southern coast of the Ohrid lake, located 100 m below the Prespa Lake.

A view of Prespa Lake

Based on stable isotope data measured at different springs, rivers and lakes, the contribution of the Prespa lake water to the recharge of the springs flowing into the Ohrid Lake is estimated to be 54,4 % and 37,3 % for the Tush and St. Naum springs, respectively. There are also springs found at the bottom of the Ohrid lake. The origin of these springs is more difficult to determine.

By increasing the quality and quantity of hydrological data, completing the sub-bottom lake profiles and performing tracer experiments, it is expected that the hydrological mechanisms driving the water level fluctuation of the Prespa Lake can be understood. These activities will be carried out in the second phase of the project to be implemented in 2001-2002.

Sixteen participants from the countries concerned joined a meeting in Korca, Albania, from 21 to 24 November 2000, to review the achievements and to plan future activities. Information obtained on selected topics (water balance calculation, hydrogeology/geology, isotope/water quality, sub-bottom mapping) were compiled; a workplan to carry out the above activities in 2001 and 2002 was formulated.

ISOTOPES APPLIED TO GROUNDWATER DEVELOPMENT IN AFRICA

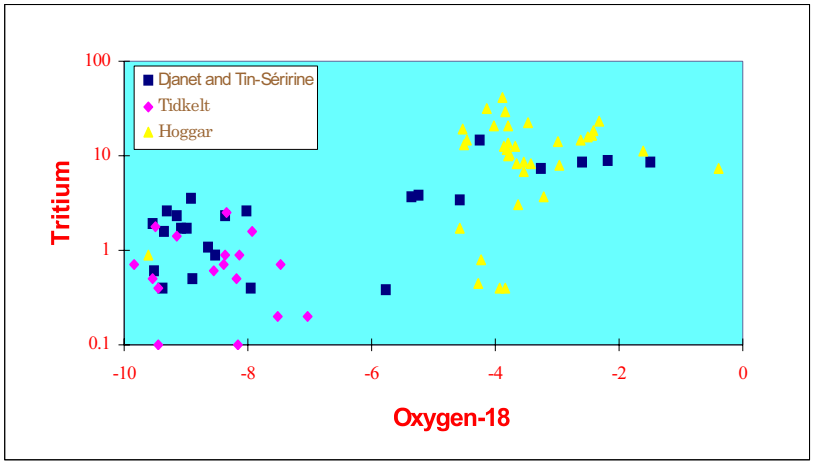
The IAEA sponsored a Regional Model Project (RAF/8/022) for Africa from 1995 to 2000, focusing on solving these problems using isotope hydrological techniques. Countries involved in the project were: Egypt, Ethiopia, Morocco, Senegal (first phase, 1995-1998) and Algeria, Mali, Niger, Nigeria and Sudan (second phase, 1997-2000).

The Final Project Co-ordination Meeting, held in Algiers, Algeria, from 9 to 15 November 2000, evaluated the overall achievements of the second phase of the project. A total of 22 project staff attended the meeting. Results obtained from field investigations carried out by counterparts in the countries in the second phase of the project were reviewed; overall achievements of phase II of the project were evaluated; and follow-up activities at the national and regional levels discussed.

Results show that isotope techniques have contributed considerably to the understanding of the groundwater systems. Main technical achievements in the respective countries can be summarised as follows:

In Algeria, the isotope results indicate that the aquifers in the Djanet (Tassili N'Ajjer) and Tin seririne (Tassili N'Ahhagar) basins, as well as in the Tidikelt region do not have modern recharge. On the contrary, a modern recharge is present in the alluvial aquifers of the Central Hoggar. Therefore, water supply for the city of Tamanrasset may rely more on the mobilization of local renewable resources through appropriate subsurface dams. Figure 1 shows the source identification plot based on stable isotope and tritium contents of the water groups.

In Mali, recharge areas of aquifers were identified by the isotopes which will serve as a guide for locating new production wells, although the cause of the piezometric depression remains unknown due to the lack of detailed geological information on the multilayered aquifer system and the impossibility of estimating evaporation from the aquifer using stable isotopes profiles in the unsaturated zone.



Tritium vs Oxygen-18 for Groundwaters in the Central Hoggar Area (Algeria)

In Niger, the isotopic results show rapid infiltration of rainfall into the shallow aquifer, with a recharge rate varying from 6 mm in the plateau to 185 mm in the northern part of the Dallol Maouri, a fossil river bed located in the southern part of the country. Four mixing zones between the deep, confined and the shallow quaternary aquifer system have been found to be most vulnerable to pollution risks. The results of this study are being used to constrain the flow and transport model of the aquifer system.

In northwestern Nigeria, the isotope study provides critical data for determination of the various sources of recharge and mechanisms involved in the replenishment of the Rima Group aquifer. This information is of the utmost value for the management of the groundwater resources in the Wurno irrigation scheme area, located in the Rima hydrological basin.

Isotope results show that the Nile recharges laterally the alluvium aquifer and the upper horizons of the Nubian sandstone aquifer. The influence of the Nile extends up to a maximum of 40 km and is not uniform. It seems to be controlled by other geological, structural and hydraulic factors, that need to be further investigated.

The deliberations of the meeting indicate that results of isotope studies conducted have substantially contributed to the improved understanding of the occurrence and origin of water in the investigated groundwater systems. Since all of the technical staff involved in the implementation of the project is from water resources development organizations, it is anticipated that the findings of the isotope studies will be fully considered in the decision-making processes with regard to water management practices.

A NEW VACUUM DISTILLATION SYSTEM FOR TRITIUM SAMPLE PREPARATION

A vacuum distillation line for water samples has been constructed at the Isotope Hydrology Laboratory. The aims of this effort were: to increase the throughput of the distillation system, to reduce sample exposure to the atmosphere, minimising any risk of tritium contamination, to allow the parallel determination of stable isotopes from the distilled sample without isotopic fractionation.

The new system is designed for parallel distillation of 20 water samples of 250ml in volume. A water sample is put into a glass bulb and heated to 40°C for distillation directly into a glass bottle which is kept cooled at 3°C in a water bath (see photo on the front cover of this issue:In front: first out of four heating cabinets with 5 individual sample distillation units, second cabinet just being closed. Each distillation unit is attached to a common vacuum pump line by a blue vacuum tube with assembled stainless steel capillary to reduce the pump rate and the moisture loss due to pumping).

Distillation time is set to five hours by restricting the steam flow rate through a glass wool packing, which avoids any transfer of liquid droplets (see photo on this page). Therefore normal sea water with an electrical conductivity of 30mS/cm can be distilled down to less than 10 uS/cm in one run. This system has a throughput about three times higher than before. Water loss is kept below 0.1ml and therefore well below a per mil fraction of the water mass, avoiding any significant isotopic fractionation (well below 0.1‰ for $\delta^{18}O$ and 1‰ for δD). This allows the measurement of stable isotope ratios on the distilled water from saline samples.

Left side: heater with glass bulb for original sample; above visible the white glass wool; right side: glass bottle in water cooling bath with red lead ring (against buoyancy); above visible the blue vacuum hose with steel capillary (0.2mm in diameter) and at the right side a manometer as leak detector.

The direct transfer of original water into the storage bottles minimizes possible contamination risks due to sample exposure to atmospheric air. A comparison of the most important features of the formerly used distillation at ambient pressure and the new developed vacuum distillation system used at the Isotope Hydrology Laboratory is given in Table 1. The new vacuum system has been in operation in the laboratory since December 2000 and has replaced the formerly used system.

Table 1: Comparison of the Two Water Distillation Systems

Parameters	Conventional Distillation	Vacuum Distillation
no. of distillation units	12	20
time for a distillation	4 hours (one per day)	6 hours (one per day)
temperature (heating)	100°C	40°C
temperature (cooling)	15°C (tap water cooling)	3°C (water re-circulator)
water amount	250 g	250 g
water loss	1-2 g	<0.1 g
reduction of electric conductivity	100×	>1000×
stable isotope fractionation	yes	no
no. of distillations to obtain water with <10μS/cm		2

IAEA Meetings in 2001

RC-791.2
Response of hydrological systems to long-term exploitation
2-6 April 2001
Vienna

RC-826
Isotopic composition of precipitation in the Mediterranean Basin in relation to air circulation patterns and climate
17-20 April
Vienna

AG-2001.3
AGM on the state of the art and development needs for integrating GNIP data and hydroclimatic models
9-12 April
Vienna

CN-80
International Conference on the study of environmental change using isotope techniques
23-27 April
Vienna

AG-2001.1
AGM on the state of the art and development needs for noble gas isotope applications in geothermal reservoir exploration and monitoring
25-28 June
Vienna

AG-2001.2
AGM on the assessment of the state of the art in isotope applications for integrated water resources management (jointly with UNESCO)
10-13 Sept.
Vienna

AG-2001.4
AGM on the development of an action plan for integrating isotope hydrology in the water sector of Member States
22-25 Oct.
Vienna

NOTICE OF STAFF CHANGES

In the year 2000, Mr. Edmundo Garcia-Agudo, Ms. Jane Gerardo Abaya and Mr. Yuecel Yurtsever left the Agency.

Mr. PANG Zhonghe joined the Agency last April.

Editor's Note

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