Isotope hydrology helps find water fit to drink

A programme of the Regional Cooperative Agreement for Research, Development and Training in Nuclear Science and Technology in Asia and the Pacific (RCA)

Clean drinking water is in short supply in Asia and the Pacific. More than one billion people live in conditions of 'water stress', where population growth, increasing per capita consumption, and competition between agricultural, industrial and domestic users are placing an overwhelming strain on limited freshwater resources. Furthermore, a vast proportion of these limited resources is too saline to drink or too contaminated to drink safely. Salinity is an increasing problem due to excessive irrigation and over-exploitation of groundwater generally (when the freshwater table gets very low, water from the sea flows inland to replenish it). Other contamination arises from industrial and agricultural pollutants such as heavy metals, sulphates and nitrates, from natural toxins such as arsenic, fluoride and polyaromatic hydrocarbons, as well as from a variety of microbial hazards, especially faecal coliform from sewage. The result? Two out of five people are drinking water considered unsafe by international standards. Finding, managing and protecting clean drinking water is therefore a major regional challenge.

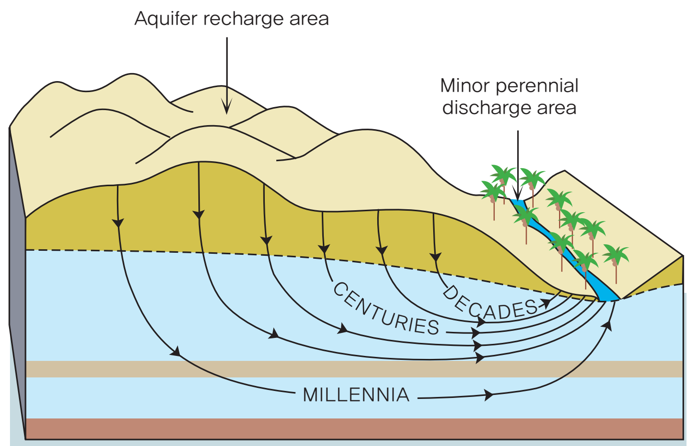
The gravest drinking-water threat in many parts of the region is from arsenic. Arsenic occurs naturally but is poisonous above a certain level (10µg per litre of water, according to the World Health Organisation). Over a 5-20 year period, arsenic-rich water can cause skin discolouration; lesions on feet, chest and hands (pictured); cancers of the skin, bladder, kidneys and lungs; diseases of the blood vessels in legs and feet; and possibly diabetes and reproductive disorders.

Millions of people in the region still drink water containing dangerous concentrations of arsenic. Worst affected has been Bangladesh, where the contamination of one in four shallow groundwater wells put 70 million people at risk. In a project run jointly with the IAEA and the World Bank, the RCA used isotopic investigative techniques to help locate deeper aquifers that could be used as an alternative and sustainable source of safe drinking water.

In response to this situation, the RCA has undertaken a long-term programme to help countries develop the skills and facilities to use isotopic (nuclear) tools and techniques, which allow very sensitive and often unique insights into the behaviour of water resources. This has greatly improved national and regional capabilities for assessing the quality of existing water supplies and for identifying alternative and sustainable sources of clean drinking water for the future. The programme, supported by the International Atomic Energy Agency (IAEA) under its Technical Cooperation Programme and initially in partnership with the United Nations Development Programme (UNDP), has involved technology transfer, human resource training and development, and investment in physical infrastructure.

Initially the RCA-assisted studies focused on the problems of freshwater supply and sustainability, the salinization and contamination of groundwater, and the evaluation of alternative groundwater resources for potential sustainable exploitation. Subsequent studies assessed the impact of industrialization and urbanization on the quality and quantity of water resources by targeting areas where local populations were considered to be at risk. These studies have had important results. Before they were undertaken, for example, most participating countries had no baseline data for toxic contaminants such as arsenic and fluoride. The studies revealed that these kinds of contaminants are more widespread in the region than previously thought.

Isotope techniques employ isotopes of the elements of water and of some dissolved salts as natural tracers. These have the advantage of directly providing information on processes undergone by the water itself without introducing any additional pollution. In addition, isotope measurements can provide information on how old the groundwater is and where it originally comes from; how it is recharged (from what sources, under what conditions, at what rates does it take days, months, years or millennia to replenish?); what its 'flow' patterns are; how it interacts with other aquifers and with surface water and sea water; its vulnerability to man-made pollutants, natural contaminants and saline intrusion; and how and where these impurities enter the groundwater and are then 'transported' by it elsewhere.



This conceptual model of Shijiazhuang aquifer in China illustrates the groundwater 'cycle' including recharge, discharge and pollution mechanisms.

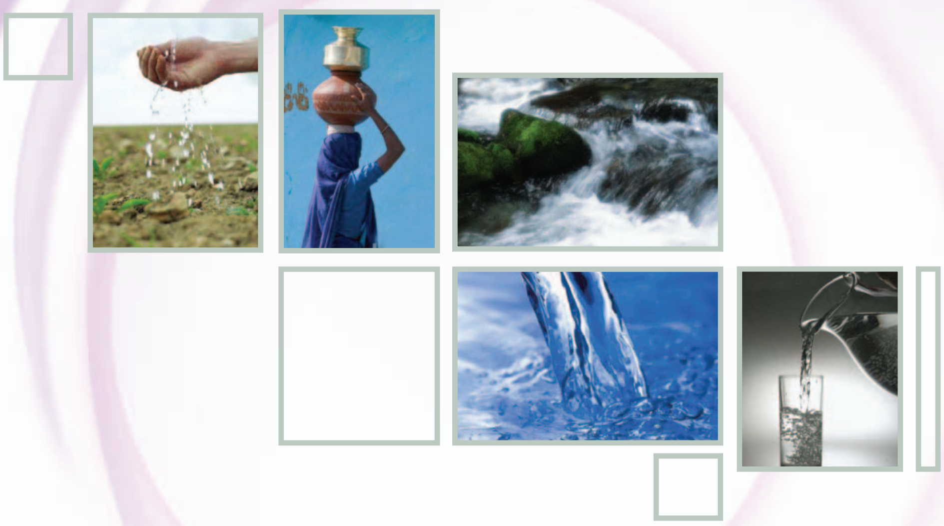
Isotope measurements used in conjunction with data gathered by conventional hydrological methods (hydro-geological, chemical, biological, etc.) extend the application of this data to provide invaluable information about the source and movement of water in different environments both above and below ground, including rivers, lakes and aquifers. This isotope data can also help validate and improve the numerical models based on conventional analytical methods and assist in the overall planning and management of a water resource.

The science by itself is not going to solve the problems without the participation of local, national and regional authorities. The RCA programme has also been helping to address this issue by encouraging the authorities to adopt a more collaborative and comprehensive approach to the collection of hydrological data. Interconnected problems can only be addressed effectively by coordinated and sustainable water management policies and practices based upon sound scientific evidence.

The RCA's work has brought isotope techniques to the attention of water resources managers and policymakers throughout the region. The demonstrated combination of nuclear and conventional hydrological techniques has produced more accurate assessments and predictions of groundwater behaviour, which in turn has enabled the development of better informed and more sustainable policies for using and managing the region's clean drinking water resources. The Philippines and Thailand, for example, have established protection zones for aquifers. Malaysia has enacted controls on the effects of mining activity on groundwater dynamics. Indonesia has set up a safe groundwater exploitation zone. Korea has characterized the flow paths of fluoride-bearing waters. India is now confident of selecting safe waste disposal sites and has prohibited the use of arsenic-contaminated shallow aquifers for drinking water. And Pakistan has investigated an arsenic pollution threat in the Indus Basin and developed a groundwater flow model for safe and sustainable management of Lahore aquifer to supply good quality water.

Isotope techniques are becoming essential tools in hydrological research, and the number of organisations adopting them in Asia and the Pacific continues to grow. Importantly the training, technical assistance and field studies facilitated by the RCA have given scores of local practitioners the skills and experience to ensure that isotope hydrology is here to stay.

Collecting water samples from a pond in Malaysia which has been created by the decomposition of waste from landfill.



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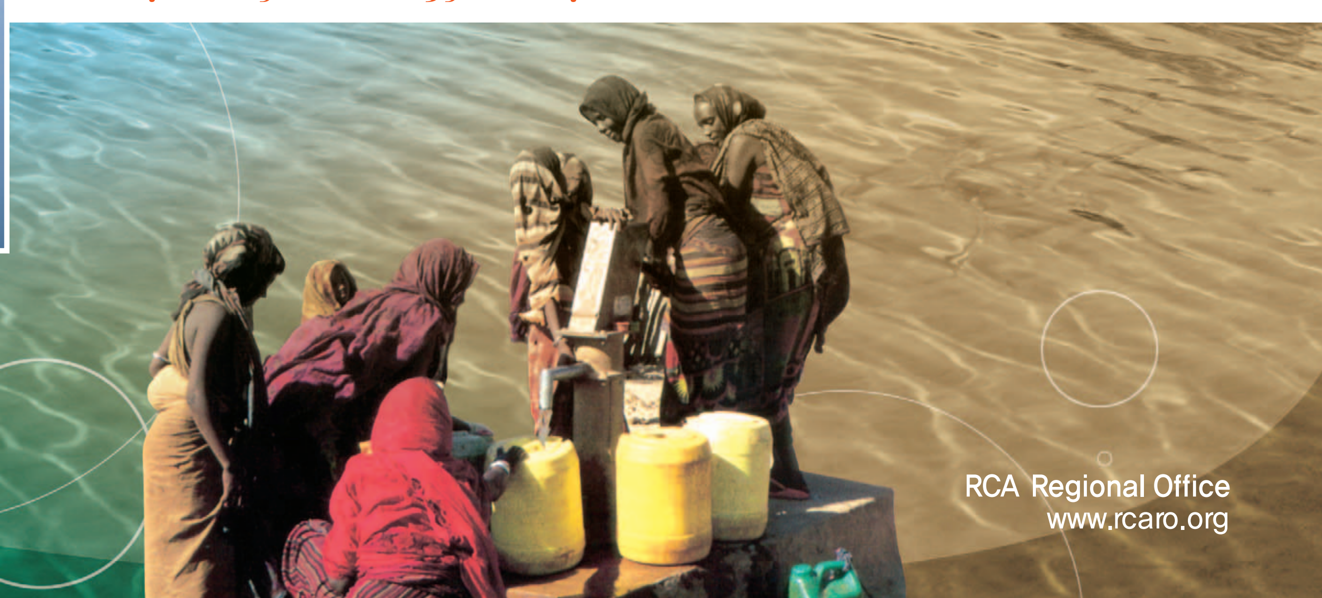

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