One of five key areas to sustainable development where progress is possible with the resources and technologies at our disposal today.

Managing Water Resources using Isotope Hydrology

Of all the water on Earth, only 2.5 per cent is freshwater, the rest is salty. Of this freshwater, most is frozen in icecaps, present as soil moisture, or inaccessible in deep underground aquifers, leaving less than 1 per cent accessible for use.

Sustainable human development is dependent on the availability of water. It is estimated that more than one third of the global food production is based on irrigation, a significant portion of which may rely of unsustainable groundwater sources. Despite progress in the last two decades to improve access to safe drinking water, some 1.1 billion people today go without it. Areas of water scarcity and stress are increasing, particularly in North Africa and West Asia. In the next two decades, total water demand is expected to increase by 40 per cent. By 2025, two-thirds of the world's population may live in countries with moderate or severe water shortages.

The challenge is how to manage this finite resource, today and in the future. Given that fresh water resources are very often shared by more than one country within a region, international and national action at all levels will be needed to improve access in those regions lacking water and to improve the efficient use in those regions that have water today, so that these supplies can be sustained for future generations.

Key to sustainable management of water resources is having the knowledge needed to make the right decisions. Isotope hydrology is a nuclear technique that uses both stable and radioactive environmental isotopes to trace the movements of water in the hydrological cycle. Isotopes can be used to investigate underground sources of water to determine their source, how they are recharged, whether they are at risk of saltwater intrusion or pollution, and whether they can be used in a sustainable manner.

During evaporation and condensation, the concentration of oxygen and hydrogen isotopes in a water molecule undergo small changes. As a result, in different parts of the hydrologic cycle, water is naturally tagged with isotopic fingerprints, which vary according to the history of a particular body of water and its route through the hydrologic cycle. Isotopes are atoms of an element that are chemically identical, but physically different. Nuclear science is able to distinguish them using mass spectrometry to "weigh" them.

Monitoring the Hydrological Cycle using Isotopes

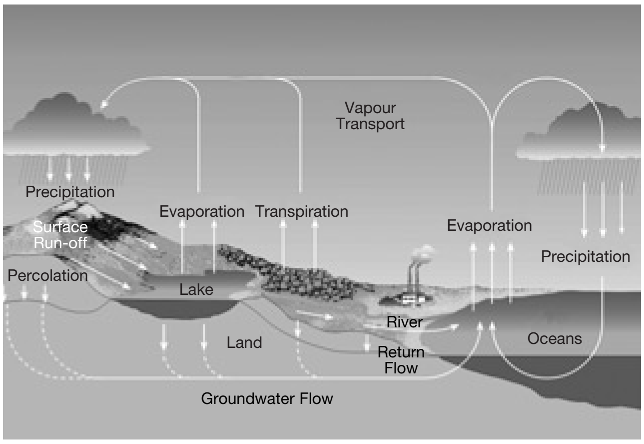

Illustration of the hydrological cycle

Both hydrogen and oxygen, the elements of water, possess mostly light isotopes. When water from the ocean evaporates, the heavier isotopes will condense first and fall as rain before the lighter ones. Most water vapour in the atmosphere is generated over oceans. Thus, the further rain falls from the coast, the fewer heavy isotopes it contains.

At each stage of the hydrological cycle, there is a small change registered by a difference in the concentration of oxygen and hydrogen isotopes in water that is as unique as a fingerprint. The isotopes of pollutants, such as trace metals, or chemical compounds dissolved in water, also offer clues about its origin.

The picture that emerges allows hydrologists to map groundwater sources and climatologists to better assemble climate history, setting signposts for the impact of future events as climate change occurs. Isotopes open a window onto extended periods of weather events over thousands of years. Their signatures are preserved wherever the water cycle is recorded, in ocean and lake sediments, tree rings, glaciers and ice caps, deposits in caves and groundwater.

The International Atomic Energy Agency (IAEA) supports the use of isotope hydrology to improve knowledge of water resources. Each year, the IAEA allocates nearly US $3 million to its water resource programme. The Agency has also invested about US $30 million in 150 projects in 60 countries to improve water management using isotope hydrology and, in the process, has trained hundreds of young scientists. Isotopes are a powerful tool and can be also used to investigate dam and reservoir leakage, to help determine the source of water pollution, and to identify suitable underground reservoirs for steam supply to geothermal plants.

Building Regional Capacity

One focus of the Agency's the technical co-operation programme is to facilitate co-operation among developing countries to help build local expertise in isotopic techniques. With this approach significant strides have been taken in developing such expertise in Africa and Latin America.

A regional project in Kenya, Madagascar, Namibia, South Africa, Tanzania, Uganda, and Zimbabwe is aimed a building regional capacity to undertake isotopic techniques and analysis as part of their investigation of groundwater resources. As a result of this regional project, a modern analytical facility at the University of Witwatersrand, South Africa is now well on its way to becoming a self-supporting analytical centre for the region. Countries participating in the regional project are now able to incorporate isotopic analysis as part of their hydrological investigations. Tanzania is also using data gathered from the project in devising protection plans for their groundwater.

A similar regional project in Latin America involves 30 institutions in Chile, Colombia, Costa Rica, Ecuador, Paraguay, Peru, and Uruguay that are now using isotopic and conventional techniques to gather data about an aquifer system. Together, the institutes are working to address problems with water shortages and management of resources in the region. A new regional project was begun in 2001 to incorporate isotopic techniques in a Global Environment Facility project on the environmental protection and sustainable development of the Guarani aquifer — a large freshwater aquifer in Argentina, Brazil, Paraguay, and Uruguay.

For nearly 40 years, the IAEA and the World Meteorological Organization (WMO) have maintained a global network monitoring isotopes in precipitation. The Global Network for Isotopes in Precipitation (GNIP) monitors isotopes in precipitation providing the ability to understand the processes influencing the amount and geographic distribution of precipitation and a base-line for other work. The monitoring network may be expanded in the future to include monitoring of rivers. Such a network would provide useful reference data for climate change studies and basin scale analysis of rainfall-runoff relationships, enhancing the data already available through GNIP.

Searching for Solutions

Isotope hydrology is a very cost effective means to assess the vulnerability of groundwater sources to pollution. By determining how rapidly the water is moving and where in the system is being recharged, isotopes provide critical information to guide decisions on where to extract water. Such decisions can sometimes mean the difference between prosperity and misery. In Bangladesh, many communal tube wells contain high levels of natural arsenic. Established in the 1970's as an alternative to unsafe contaminated surface waters, these tube wells have caused significant illness, disability, and even deaths from the insidious effects of slow arsenic poisoning. International efforts to test the wells and identify those with unacceptably high level of arsenic are now underway with support from the World Bank and others, but it may take many years to find long term solutions to this complex problem. Through a World Bank project, the IAEA is working with a non-governmental agency in the region to investigate whether deep aquifers will remain arsenic free if they are developed as alternatives to the tube wells and to better understand how other aquifers may have become contaminated with arsenic. The data from this isotope hydrology project will help water managers identify safe and sustainable water supplies in Bangladesh.

Sustainable use of water resources is a global responsibility. Through the hydrological cycle, all water on Earth is affected by human activity. With the prospect of growing water scarcity looming ever more real, decisions on where to extract water, how much of it to use, and how to manage it must be based on reliable information, if we are to protect this precious water resources for future generations. Isotope hydrology is an important tool being used around the world to provide the information needed to make the right decisions today and for tomorrow.

More information is available on the Agency's WorldAtom website:
http://www.iaea.org/programmes/ripc/ih/index.html

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