XA0301002

INIS-XA--615

Groundwater resources in Southern & Eastern Africa

Water shortage, water quality, and the protection of investments in water supply, are of continuing concern to countries in Africa. As more countries join those already short of water, sound management of groundwater resources becomes more critical. Isotope techniques provide information that is unobtainable by other means and help to achieve a better understanding of mechanisms and processes through which water resources can be managed. The International Atomic Energy Agency is sponsoring a regional technical co-operation project addressing practical issues related to water resources assessment and development in Kenya, Madagascar, Namibia, South Africa, Tanzania, Uganda and Zimbabwe. The project also seeks to strengthen isotope hydrology capacity in the sub-region.

SHORTAGE OF WATER is an issue of growing concern on the African continent. Despite investment of hundreds of millions of dollars in new water supplies, results are often disappointing and management problems appear to be the single greatest cause of misallocation and waste. Even where surface water is abundant, rivers and lakes may be contaminated with disease-causing organisms such as guinea worm or bilharzia. In such cases, groundwater may be an alternative. Elsewhere, groundwater supplies may be threatened with pollution or increasing salinity. People have a right to clean water and governments are under pressure to ensure that they get it.

It is no good sinking boreholes when groundwater is to be extracted at a rate which exceeds natural replenishment, or causes saline or contaminated water to be drawn in. Sustainable supply can only be assured through proper management based on sufficient knowledge of the groundwater system being tapped. The lack of such knowledge may lead to the perpetuation of inefficient use, and to new conflicts over water rights.

People have a right to clean water.

MICHAEL PICKSTOCK/WRENmedia

Isotope techniques

Environmental isotopes provide knowledge about water that cannot be obtained in any other way. Environmental isotopes, at concentrations set by natural and man-induced processes, give a "fingerprint" to a body of water which traces the water even as it moves from one system to another. Isotopic data is carried within the water molecule itself *(see box)* and in some dissolved substances. Radioactive environmental isotopes which decay with time can be used to assess the rate of movement of groundwater. Fast-moving (recent) groundwater clearly is rapidly replenished and suitable for regular exploitation. Slow-moving (ancient) groundwater may be suitable only as an occasionally used emergency reserve.

Isotopes can therefore be used to:

- evaluate recharge, mixing and discharge of aquifers and identify fossil water;
- define aquifer vulnerability to over-exploitation and pollution;
- evaluate mixing between surface water in rivers and lakes and adjacent groundwater;
- determine the water balance of lakes and reservoirs; and evaluate source of salinization.

Isotopes of the water molecule are of special interest to hydrology. Deuterium (hydrogen-2) and oxygen-18 are heavier and much more rare than the more abundant isotopes hydrogen-1 and oxygen-16. Tritium (hydrogen-3) is even rarer and radioactive. Water vapour rising from the oceans has a lower concentration of the heavy isotopes than sea water. When the resulting clouds release their water, the heavy isotopes rain out first. This means that rain changes isotopically as clouds move inland. In the process, water acquires individual and characteristic fingerprints in different environments. The decay of tritium "dates" groundwater over decades; radiocarbon in dissolved lime can "date" many millennia. Analysis of a water sample can reveal its age, origin and how it got there.

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Practical applications

There have been many instances of major investment by national governments and donors to improve water supply by sinking boreholes. Geophysical hydrology may have located a substantial groundwater resource, but boreholes have quickly run dry or become saline. Not only has investment been wasted, but traditional hand-dug wells, on which people previously relied, may also fail, leaving them in a far worse situation. The Model Project will be developing regional isotope hydrology expertise and facilities to provide data which in combination with those derived from conventional techniques will assist in avoiding such economic and social disasters in participating Member States.

Kenya - to define recharge from the Ewaso-Nyiro River to regional aquifers. The sources and rates of recharge to these aquifers are unknown, as are the relations between them and the Ewaso-Nyiro River. Isotope hydrology should reveal the answers.

Madagascar - to investigate the sources of salinity of groundwater in fractured aquifers in the arid south of the island. Some 30% of boreholes sunk by UNICEF encountered unpotable water - a major waste of investment. Isotopes can assist in understanding the link between salinity and the nature of fractures in order to improve success rate in future major drilling programmes.

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Sampling water for isotope analysis from a UNICEF hand pump in southern Madagascar.

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Demonstrating field extraction method for radiocarbon analysis in Uganda.

Namibia - to assess recharge to the south-east artesian basin at Stampriet. Although the basin has been studied extensively, also with isotopes, crucial questions regarding the areas and nature of recharge and its quantification remain unanswered. A new strategy to tackle these problems with further hydrologic and isotope studies is being developed.

South Africa - to define recharge and storage capacity of fractured-rock aquifer systems in the Northern Province which is home to 3.6 million people. Isotope hydrology will help to meet the demand for new community services in these former homelands.

Tanzania - to investigate pollution and depletion of groundwater resources in the Mokutapora basin, the sole source of water for one million people in the capital city of Dodoma. Isotope data will provide a basis for regulatory action and resource management.

Uganda - to investigate the connection between shallow and deep aquifers and their recharge patterns. Isotope data will help refine a drilling strategy and establish borehole protection zones in the catchment area of Iganga and Wobulenzi, Southern Uganda.

Zimbabwe - to investigate the interaction between the Save River and recharge/discharge of bordering aquifers. Threats of salinization and pollution result from heavy agricultural use. Isotope data will help in the design of a management strategy to protect both resources.

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