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Water resources for Africa

Water scarcity is a matter of urgent, national, regional and international concern. For those people, usually women, who are responsible for the daily task of obtaining sufficient water for household use, water shortages are a perpetual worry. It is a situation which affects many individual families and communities throughout the arid and semi-arid regions of Africa. The isotope studies conducted thus far have proved that the majority of regional groundwater systems in northern Africa and the Sahel zone are paleowaters, replenished thousands of years ago, without the possibility of significant replenishment under present climatic conditions. Therefore, removal from such underground reservoirs will eventually deplete the resource. Mapping these paleowaters, and estimating their reservoir sizes, is a priority.

Rising populations are putting increased pressure on existing water supplies. Water is being extracted from underground aquifers at a rate faster than it is being replenished. Furthermore, water resources are becoming more vulnerable to the risk of pollution from human activities of all kinds. With careful management, water should be an infinitely renewable resource but this depends on correct analysis of water availability and water use. Isotope hydrology may be the only tool that can be used to gain this knowledge.

Before investing in industrial development at a particular location, the available water resources must be investigated. Isotopes can be used to identify the age of the local groundwater. In one case, it was found to be 20,000 years old, indicating that the groundwater had no contact with replenishable water resources. Had it been tapped, this supply of water would have run dry and a large investment wasted.

Isotope hydrology also identifies the balance between precipitation and transpiration. The concentration of the tritium isotope in the groundwater of the Kalahari desert in Botswana was found to be comparable to that of the region's rainfall. This confirmed that a fairly quick recharge occurred and that the water could be used on a sustainable basis.

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Water shortage and drought - a persistent and increasing problem

Discharge and recharge of aquifers

Without a detailed knowledge of water flow patterns it is impossible to design rational development plans for using groundwater resources, especially those in deep, confined aquifer systems. In the case of shallow, unconfined aquifers, like wadi underflows, it is essential to assess the average renewal rate of the system, whether recharge occurs on an annual basis, or if it is due only to exceptional rainfall.

Pollution

The risk of pollution from returning irrigation water can be assessed by determining the area from which an aquifer is recharged. The rate of evaporation can also be assessed and this provides valuable information about the risk of soil salination.

Mixing between water

Before developing new sites for water extraction, the impact on nearby water bodies must be measured. Isotopic hydrology can be used to determine underground mixing between aquifers and mixing between lakes, rivers and aquifers.

What can isotopic techniques do?

Isotopes can identify a body of water even as it flows from one water system to another because the isotopic description is within the water molecule itself. Coloured dyes, floats and markers can all be used to mark water movement and chemical analysis identifies the chemical characteristics of a body of water, but these are crude tools compared to the level of certain identification that only isotopes provide. They can be used to:

- identify the origin and dynamics of water resources
- evaluate recharge and discharge of aquifers
- define aquifer vulnerability to over-exploitation and pollution
- evaluate mixing between surface (river and lake) and adjacent groundwater
- determine the water balance of reservoirs
- evaluate possible recharge of local groundwater resources.

Comparative uses of water

Source: FAO

Water quantity and quality requirements differ widely depending on use. Agricultural requirements are especially large in relation to other uses, as can be seen by comparing possible uses of the 15,000 cubic metres of water normally needed to irrigate one hectare of rice.

In arid and semi-arid regions, rainfall is of paramount importance. In Botswana, for example, the unit of currency is the 'pula' which means 'rain' and each pula is divided into one hundred 'thebe' or 'raindrops'.

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Artificial or environmental isotopes?

Artificial isotopes are used primarily to solve relatively local hydrological problems such as leakage from dams, or for defining groundwater protection zones.

Environmental isotopes are the only means of identifying paleowater. This can be done by measuring the radioactive isotope carbon-14. Measuring the level of deuterium, tritium and oxygen-18 also provides dating evidence because, as the world's climate has changed over the millenia, the isotopic composition of water has also changed. This occurs because, during ice ages, ice caps lock up more of the lighter isotopes, which are preferentially evaporated and then precipitated in polar regions. In arid regions, paleowater recharged during pluvial phases of the climate, has a distinct isotopic signature compared with recent rainfall in these areas. This climatic imprinting can be used by hydrologists to date groundwater resources.

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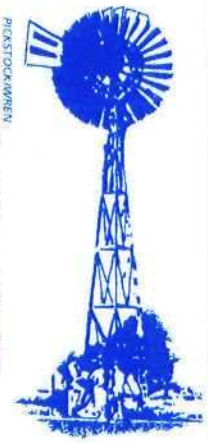

Careful management of water resources is essential if these children's children are also to enjoy a plentiful supply of water.

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Water - a scarce and precious resource upon which humanity depends for its existence.

Model Project - the IAEA initiative

The Agency's activities in isotope hydrology in Africa started in the early 1980s in the Sahelian countries and were later extended to East Africa. National and regional co-operation projects develop and strengthen manpower skills and infrastructure.

The Africa Regional Groundwater Model Project expands and enhances the use of isotopic techniques and puts strong emphasis on the involvement of the end user. A further objective of the Model Project is to strengthen regional capabilities and regional co-operation.

Ethiopia

Three million people in the Moyale region of Ethiopia are at risk from recurring droughts. The Ethiopian Water Works Construction Authority wants to provide them with adequate water supplies on a sustainable basis. It is therefore essential to know the natural replenishment rate of water in the region. Isotope hydrology will provide the data.

Senegal

Water resources in Dakar and its immediate surroundings are inadequate for the rapidly growing city. The Ministry of Water Resources has to determine the water balance in the area's aquifers before being able to design rational management of the resources. One and a half million people should benefit.

Morocco

Half a million people in Morocco depend on aquifers at Tafilafel, Guelmim and Afendul Lahajar for their drinking water and for water for irrigating their crops. Isotopic hydrology studies will provide information on evapo-transpiration, infiltration rate, origin of salinity, mixing ratio between aquifers and the most suitable recharge sites.

Egypt

Isotopic techniques will be used to assess the recharge rate from the Nile aquifer to the Western Desert fringes in Egypt - essential information for the development and reclamation of agricultural land. Information about the origin of agricultural pollution will allow a water management programme to be put in place.

Impact of the Model Project

In the short term, data obtained from hydrological studies will be used to estimate recharge rates and water budgets in the countries concerned. This will lead to the development of guidelines for water policy and optimum management of existing resources.

In the longer term, regional capabilities and facilities will be strengthened and experience will be gained. This should lead to more judicious use of water, a scarce and precious resource upon which humanity depends for its existence.

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