Isotope Hydrology in Latin America

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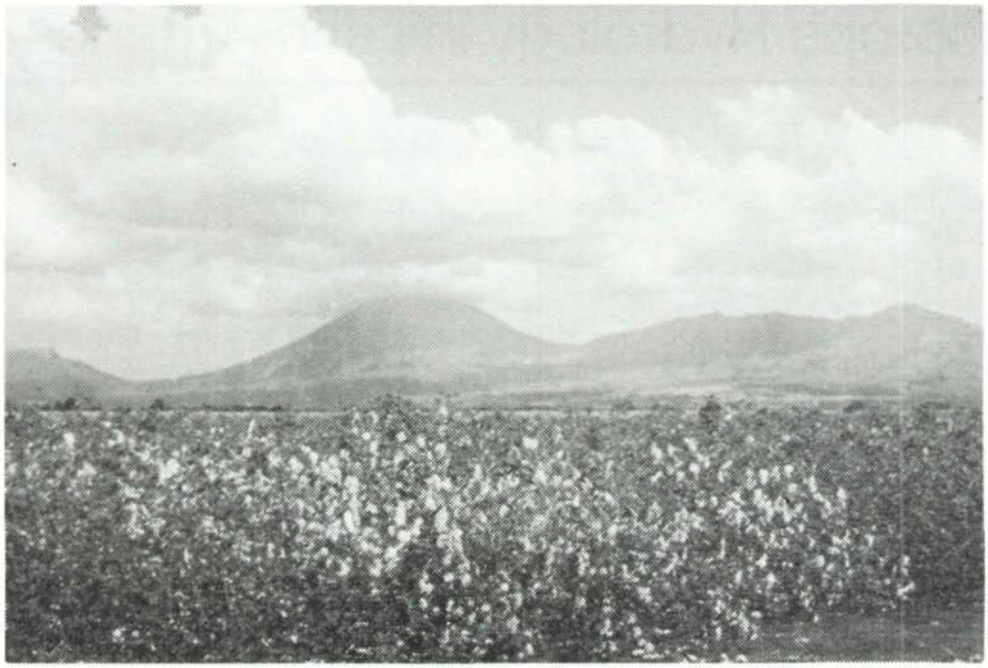
There are a broad range of nuclear techniques applicable to a variety of hydrological problems and these techniques are becoming recognized as an additional and, in some cases, indispensable tool available to the hydrologist in his quest to meet the increasing demands for water by agriculture, industry and community water supply. In Latin America we find examples of almost all the nuclear hydrological techniques. This article endeavours to give a summary account of the status of isotope hydrology in the region and the types of problems to which these techniques have been applied.

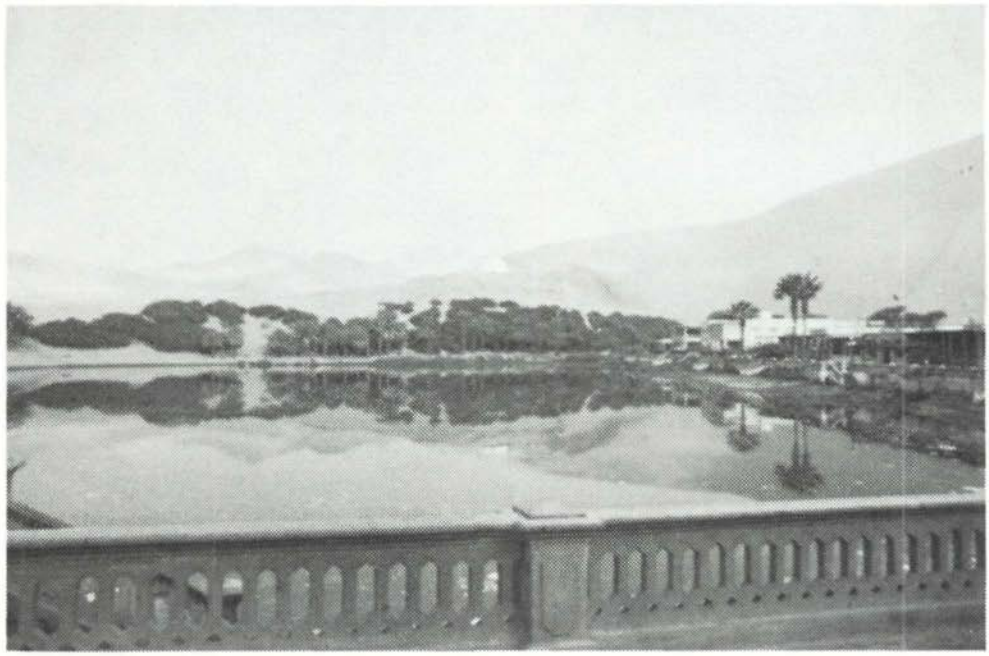
A knowledge of the movement of sediment is of importance in, for example, keeping navigation channels clear, deciding the location of cooling water intakes to power stations and investigating the problem of silting up of reservoirs. Radioactive tracer techniques have already made valuable contributions to such problems. The Argentine Atomic Energy Commission has employed these techniques in connection with the maintenance of the access channel from the River Plate to the port of Buenos Aires. Similar problems have been tackled in Brazil and Chile with technical assistance, which included expert help in the integration of the radiotracer and conventional techniques, by the IAEA. A group at IPR Belo Horizonte is working on laboratory models and sediment transport in rivers with an emphasis on quantitative interpretative methods. These techniques have also

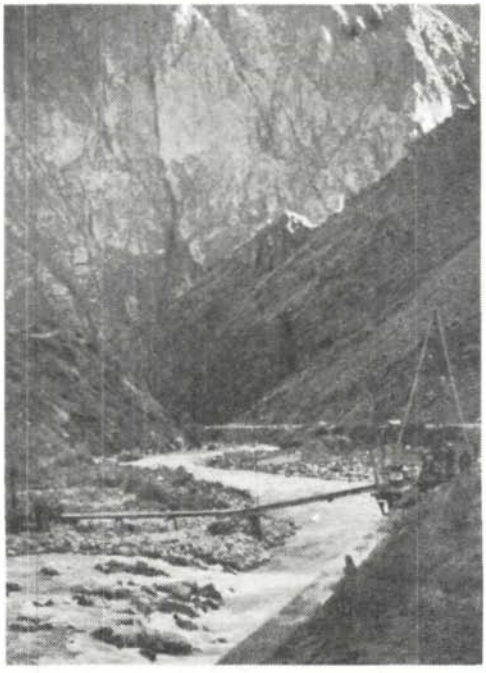
Aerial view of the diversion of water from the Morelos reservoir on the Colorado River for irrigating the Mexicali Valley in Mexico. Environmental isotope techniques are being used to study problems of the origin of water and salinity. Photos: IAEA/Payne



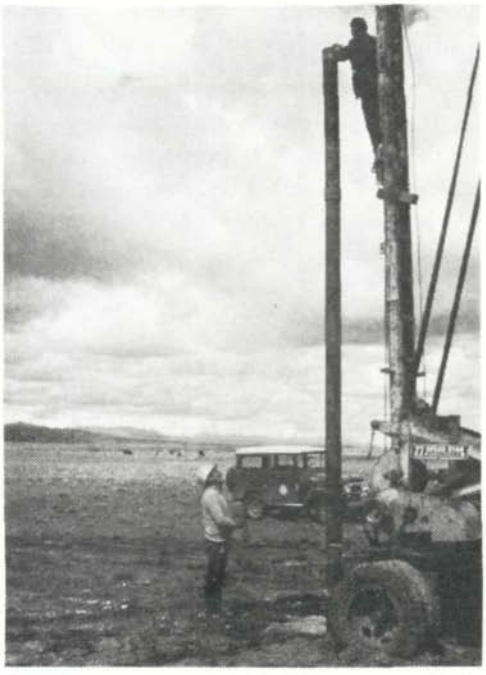
A cotton plantation on the Chinandega Plain, Nicaragua, where the IAEA co-operated in a large-scale UNDP project and found that the groundwater originates from infiltration of precipitation falling on the mountains at elevations in excess of 280 metres.

An oasis in the coastal desert south of Lima, Peru. A special mission from the IAEA advised on the use of isotope techniques for the development of groundwater resources in the region.





Rio Rimac in the lower Andes, Peru. The IAEA advised on the feasibility of gauging the discharge of the river with radioisotopes in connection with the siting of a proposed hydroelectric tunnel intake.



Sampling water for environmental isotope analysis in the Altiplano, Bolivia, to study the origin of groundwater as part of a large-scale UNDP project to appraise water resources.

A pumping test in Jamaica where the IAEA carried out isotope studies for a UNDP project.

been used in Mexico for a number of studies, including the movement of sand in the Gulf of Mexico near the proposed site of a nuclear power station at Laguna Verde. A French team has used these techniques in Lake Maracaibo in Venezuela.

Radioisotope techniques are available for measuring the direction and velocity of groundwater flow in boreholes. Such information is particularly valuable in problems associated with hydraulic structures, such as leakage through dams and movement of groundwater in the vicinity of refuse disposal dumps. In fact, the first applications of this method in Latin America date back to the early 1960's in Chile.

Nuclear logging applications in hydrology are not as yet so widely applied as in the petroleum industry. However, they provide valuable information on many hydrological and geological parameters which are of importance in the optimum development of groundwater resources. Currently, Cuba is receiving assistance from the IAEA to broaden the range of nuclear logging capability in the country.

Problems of pollution are increasing in importance in many parts of the world and the Latin American region is no exception. Radioisotopes are used to study the dispersion and diffusion properties of proposed effluent sites and in fact have been used in Brazil to study the disposal of waste from Santos to the ocean. Undoubtedly this type of study and also that of the transport mechanism in estuaries is likely to increase in future.

A whole group of hydrological applications is derived from environmental variations in the isotopic composition of natural waters. The most commonly used environmental isotopes are the stable isotopes deuterium and oxygen-18, and the radioisotope tritium, which are all part of the water molecule, and carbon-14, which occurs in the dissolved carbon in water. This group of applications differs from other applications in that the size of the area which can be studied may extend up to thousands of square kilometers. Furthermore, no radioactivity is introduced into the system, rather measurements are made of the naturally occurring radioisotopes which are produced in the environment. The fact that three of the isotopes are actually part of the water molecule results in them being ideal tracers of water. These environmental isotope techniques are being used more and more in water resources investigation, particularly in groundwater studies. Indeed, it should be remarked that these studies have been used, or will shortly be applied, in almost 60 percent of the member States in Latin America.

Problems associated with the origin of recharge of groundwater provide a unique example of application of environmental isotope techniques. In Nicaragua the Agency contributed, by its own staff and laboratory, to a large scale UNDP project. It was found that deep groundwater in the Chinandega coastal plain was recharged at elevations greater than 280 metres, rather than by infiltration of precipitation which falls directly on the plain. Environmental isotopes data have also contributed to the elucidation of origin and movement of groundwater in the Altiplano in Bolivia. In addition, the IAEA will be participating shortly in a large-scale UNDP project that will investigate groundwater in the neighbourhood of Guatemala City.

In arid areas problems of salinity of waters pose a severe constraint on development of agriculture and community water supply. Problems of salinity are common in the north-eastern area of Brazil and the national isotope hydrological groups at Piracicaba and Belo Horizonte are engaged in studying the reason for the occurrence of these saline waters. Brazil now has the analytical capability for all the commonly used environmental isotopes

and is acquiring experience in the use of these techniques. The Brazilians are also engaged on the possible use of environmental isotope data to study the water balance of the Amazon River Basin. In particular it is hoped that the data will provide some indication of the extent of recycling of water to the atmosphere by evapotranspiration within the basin. The practical aspect of this study is the plan for the substantial deforestation and settlement of the area.

The origin of salinity in the Mexicali Valley in Mexico is one of the projects forming a co-operative study between the Mexican authorities and the IAEA. The study is being carried out under the Agency's advisory services and supplements the aid provided under its Technical Assistance programme. Infiltration of poor quality surface water from irrigation canals has been demonstrated as the cause of high salinity in a number of areas in the Mexicali Valley. In another project on the coastal plain south of Veracruz, environmental isotope techniques demonstrated that most of the groundwater originates from infiltration of local rainfall rather than infiltration from the Rio Blanco which crosses the plain.

Staff at the management level from a number of hydrological organizations in Latin America were informed of the principles of isotope hydrological techniques and their potential applications to different types of problems at a regional seminar held in Mexico City in November 1973. A number of recent applications in the region can be attributed to this seminar and no doubt we shall see an increasing use of these methods as the capability is introduced into the different countries. For example, with regard to environmental isotope techniques, another two countries in Latin America will shortly have the full analytical capability required for the measurement of the isotopic composition of natural waters.

Geothermal power plant at Cerro Prieto in the Mexicali Valley where isotope techniques are being used in the evaluation of the potential of the geothermal field.