IAEA Technical Cooperation Programme

Building capacity to ensure water security and sustainability in the Central Valley of Costa Rica

The challenge

Following an extended period of drought that lasted from 2014 to 2016, the Central America region began to experience above-average tropical cyclone seasons in the years 2016–2017. The change in climate led to extensive socioeconomic damage, and the abrupt variability in rainfall of the cyclone period (dry and wet seasons) posed a challenge to the integrated management of water resources in the region.

The northern region of the Central Valley of Costa Rica provides groundwater recharge and supplies drinking water to approximately 20% of Costa Rica's population – around one million people. To prioritize resource usage effectively, government and environmental agencies need to understand the key factors controlling rainfall patterns and their relationship with groundwater recharge.

Nuclear and isotopic techniques, such as continuous hydrometric and natural tracer monitoring, can be used to better understand tropical rainfall dynamics and groundwater-to-surface-water connectivity in conditions of climate change. However, competent institutions in Costa Rica lacked hydrological instrumentation and expertise. This prevented the quantification of water budgets (the relationship between input and output of water fluxes) and meant that there was limited capacity to develop a long term integrated water resource management plan. The Government of Costa Rica approached the IAEA for support in the establishment of a hydrometric and tracer monitoring network that would provide the data needed for sustainable water resource planning and management

The project

An IAEA technical cooperation project was set up to establish a long term hydro-meteorological monitoring network that would cover the critical recharge areas of the northern Central Valley of Costa Rica. The monitoring network comprised weather stations and supported the continuous monitoring of spring and stream discharges and groundwater levels. The project also built national capacity in systematic stable isotope, radioactive isotope and noble gas sampling and analysis to determine hydrogeological responses (information about rates of water flow and recharge). In addition, a 3D groundwater model was computed to evaluate future management scenarios under a changing climate.

Sample preparation for noble gases analysis of spring water. (Photo: L. Castro/ESPH).

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PROJECT INFORMATION

Project No: COS7005

Project title: Ensuring Sustainability and Water Security in the Central Valley

Duration: 2016-2017 (2 years)

Budget: €244 000 (National partners contributed $500 000 to related activities between 2014 and 2017)

Contributing to:

Partnerships and counterparts

- Stable Isotopes Research Group, Chemistry School, National University, Costa Rica.
- Public Service Company of Heredia (ESPH), Heredia, Costa Rica.
- Foundation for the Conservation of the Central Volcanic Mountain Range (FUNDECOR), San José, Costa Rica.
- Costa Rican Institute of Aqueducts and Sewage Systems (AYA), San José, Costa Rica.

Facts and figures

- The new understanding of rainfall dynamics and groundwater recharge processes improved water resources planning, particularly for the supply of drinking water during the years of El Niño.
- A continuous monitoring network composed of weather stations, rain and steam gauges, spring systems, automated samplers and isotopic stations was put in place.
- High resolution spatial resolution isotopic maps for rainfall, groundwater and surface water were developed.
- 25 professionals were trained and a PhD thesis, Master's thesis and four Bachelor theses were completed. Five international publications were produced.
- 2911 samples were analysed for oxygen-18 and deuterium.
- Two tritium and noble gas sampling campaigns were held at 30 sites across the Barva-Colima aquifer system.
- Oxygen-18, deuterium and tritium data for rainfall in Costa Rica was provided to the Global Network of Isotopes in Precipitation Database.

Staff from several national institutions were trained in stable isotope hydrology, artificial recharge, numerical groundwater modelling, surface water tracer modelling, as well as in tritium and noble gas techniques to identify groundwater age.

The impact

The Barva-Colima aquifer system, which is critical for the supply of drinking water to the Central Valley of Costa Rica, now has in place a continuous hydrometric and tracer monitoring network. This monitoring network has allowed the groundwater recharge processes in the aquifer system to be determined using stable isotopes, tritium and noble gases. Effective collaboration between different water resource entities in the Central Valley (governmental agencies, academia and non-governmental organizations) and the IAEA was key to the success of the project.

In addition, critical recharge zones in the tropical and highly complex mountainous landscapes have been assessed. A stationary numerical groundwater model (i.e. with an annual calculation basis) was set up to conduct detailed water balances and predict water security conditions under different climate scenarios.

Thanks to the project, authorities in Costa Rica have a better understanding of the key drivers controlling rainfall generation, and the dynamics of rainfall regimes.

The science

Nuclear techniques using stable isotopes (in rainfall, groundwater, and surface water) and tritium/noble gases allowed the differentiation of groundwater recharge processes in the tropical and highly complex mountainous landscapes of the Central Valley of Costa Rica. Spatio-temporal changes in groundwater recharge are possible due to the different rainfall regimes across the northern mountain range of the Central Valley, which result in distinct rainfall volumes and seasonality. By examining stable isotopes, tritium and noble gases in water, unique 'water fingerprints' can be identified that provide important information about water flows in aquifers and groundwater recharge mechanisms over time. This information is essential for evidence-based water resource management decision making.